Iron Production in Iron Age Zimbabwe: Stagnation or Innovation?

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Thesis submitted to the University of London for the Degree of Doctor of Philosophy

Institute of Archaeology
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August 2005

Abstract

In conventional reconstructions of southern African archaeology, it has been assumed implicitly or explicitly that the production of iron was unchanging for close to 1500 years. This view was sustained despite the evidence for distinct methods of smelting that were encountered. Clearly, studies which explore the possibility of historical change in production need to be undertaken. This thesis addresses the issue of change by developing a long term perspective on iron production in Zimbabwe.

The hypothesis that change is inherent to iron production was examined through ethnohistorical/ethnographic, archaeological and archaeometallurgical investigations. Initially, iron working among the historical Njanja, Karanga and Kalanga was considered. When compared, some important similarities and differences emerged. While the principles of the technology were identical, some modifications were apparent which were peculiar to each group in areas such as the scale of production, trade and the socio-spatial organisation of technology.

Archaeological studies were conducted at Swart Village, Baranda, Nyanga and Wedza. The data obtained was supplemented with that archived in the Museum of Human Sciences in Harare. Again, there were some major outward discrepancies exhibited in aspects such as furnace types, symbolism and spatial location of production episodes. The remains from the production process were then studied in the laboratory using standard archaeometallurgical procedures.

While the production process was similar for early and later sites, constrained by the underlying principles of the bloomery process, some changes took place over time. Slag from Swart Village was tapped while that from other sites was not. The 19th century Njanja improved their furnaces by using many tuyeres and bellows which increased their efficiency beyond any known archaeological case in Zimbabwe. When viewed diachronically, the continuities and changes detected in this study demonstrate that change was an integral part of the technological past. Therefore future studies of iron production will need to take this issue of change further by constructing local histories of iron working in areas where no research has been done to broaden our knowledge of the development of the process over time.

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I am very grateful to several individuals and institutions that have generously supported me during the course of study. I would like to single out Professor Peter Ucko, the Director of the Institute of Archaeology for his assistance with funding applications and sharing with me the stress when some unexpected circumstances threatened to derail my study. In addition, Peter has been more of a father to me and I should share the success of this work with him. Still at the Institute, Professor Thilo Rehren and Dr Andrew Reid also assisted in making funding applications. Let me also extend my gratitude to Mrs Barbara Brown who together with Peter, Thilo and Andrew attended to the frequent requests that I had. In Zimbabwe, Professor Gilbert Pwiti was always ready to assist with whatever request I made. His assistance with fieldwork funds for the eastern Zimbabwe research shows his selfless nature. I would like to thank the coordinators of the Archaeology of Manyikaland Project, Professors Randi Haaland and Gilbert Pwiti for incorporating me in their project in Zimbabwe.

Financial assistance from the Wenner Gren Foundation came at a very timely moment when I was contemplating saying adios to archaeology. Over the years, I have developed a special relationship with the Foundation. The International Programmes Administrator Professor Pamela Smith helped to strengthen this relationship and the invitation to attend a special grantees conference at the Foundation in 2004 gave me an opportunity to present to the Foundation the fruits of their support and shows the confidence which the organisation has in me.

Without my supervisors Dr Andrew Reid and Professor Thilo Rehren, this work would not have achieved its present character. I can't remember the number of times that I have knocked on Andy's door for informal as well as formal meetings. Thanks very much Andy for making sure that I stay focussed in order to finish this work in time even if at times the odds were against me. Thilo Rehren was always ready to assist with the finer details of archaeometallurgy. Having introduced me to the subject Thilo's comments were thought provoking and I remember one time hitting my head because I could not comprehend what is now a very simple principle. Drs Bill Sillar and John Merkel also assisted with ideas.

Professor Gilbert Pwiti developed a great interest in my research, commenting on whatever I asked him to read. His criticism has helped me to develop critical thinking on many issues regarding the rise of complex societies in northern Zimbabwe. I do not remember the number of times that I held telephone conversations with Gilbert and in those conversations he assured me that indeed I had a future and a contribution to make to the discipline of archaeology. Many thanks for being my mentor and a source of inspiration. May the Lord bless you!

Apart from generously giving me their unpublished data for northern and eastern Zimbabwe, Drs Robert Soper and Innocent Pikirayi were constant sources of encouragement. Robert Soper accompanied me to the field to Nyanga to broaden my interpretation of iron working in the area. In addition, I would like to thank you Robert for reading my draft chapters and giving me confidence to complete this work sooner rather than later. Mr Manyanga selflessly processed my samples for ^{14}C dating despite his busy schedule and to him I say thank you very much brother. I should also thank Mr Paul Mupira for making all my fieldworks in Nyanga and Wedza possible when Gilbert was away. Dr Webber Ndoro always reminded me that it was possible to complete this work in three years and his ideas on symbolism associated with iron working are greatly appreciated. Dr Godfrey Mahachi, the Executive Director of the National Museums and Monuments of Zimbabwe awarded permits to excavate in northern Zimbabwe and helped with export permits to study the material at UCL. His members of staff were also ready to help me particularly when I was doing archival research in the Museum of Human Sciences. Ms Juliet Maradze and Mr Blessed Magadzike gave me unlimited access to their important documents and databases and to them I say thanks for this gesture of goodwill.

During the course of my study, I developed a strong working relationship with Professors Duncan Miller and Simon Hall at the University of Cape Town and David Killick at Arizona. Duncan, Simon and Dave selflessly gave me access to their unpublished manuscripts and ideas which broadened my comprehension of iron working in southern Africa.

I would not have done justice if I omit Drs Justine Bayley, David Dungworth and Sarah Paynter from the English Heritage Centre for Archaeology. David and Sarah had the most unenviable of all tasks, initially introducing me to the laboratory equipment and taking me through sample preparation, analyses and writing up of the results. To them I say here are the results of your efforts!

I also benefited from discussions with Godhi Bvocho, Lorraine Swan and Seke Katsamudanga. This work would not have been possible if I had not received the support that I got from Mukundi Chifamba and Jo Chikumbirike the technicians in the History Department. Mukundi and Jo accompanied me to the field, assisted with material analyses as well as helping me with making some illustrations. Mike Charlton, Simon Groom and Xander Veldhuijzen were always available to assist whenever I was stuck in the laboratory. Mr Stuart Laidlaw greatly assisted with photography and his insistence on detail meant that I had to learn editing photographs. Thanks so much Stuart!

Words cannot express the gratitude which I have towards Abba and the members of my family. Without them, things would have been worse. Ladies and gentlemen, the support you have given me is highly appreciated. Abba thank you very much for coping with my long absence from home and this work is dedicated to you.

The Wenner-Gren Foundation, the Ronald Tylecote Fellowship of the Institute of Archaeology Awards, and the Institute for Archaeo-Metallurgical Studies (IAMS) have generously provided funds for my tuition, fees and maintenance while The Archaeology of Manyikaland Project/NUFU, UCL Graduate School, and the Society of Antiquaries of London have kindly awarded grants for fieldwork.

Let me once again thank all those who have supported me in my academic endeavours and those whom I may not have mentioned with names. I thank the Almighty God for giving the strength and character to remain focussed and composed through thick and thin. While these individuals and institutions have assisted, errors that remain are my sole responsibility.

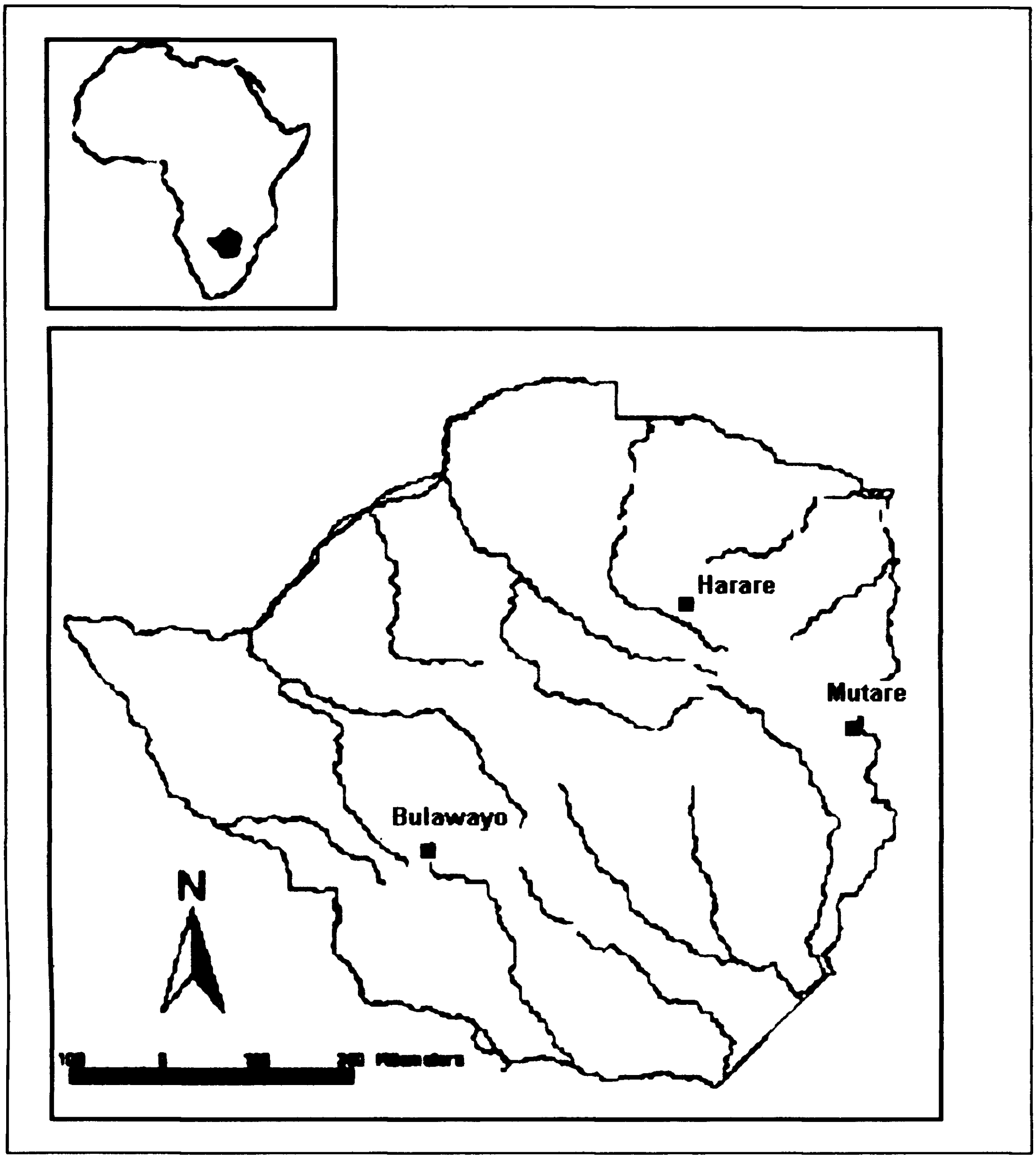
Chapter 1: Introduction

Introduction

"From about 1200 BC up to the making of iron in the present by the Negroes, the production of iron has been entirely the same that I know no way of distinguishing it... " Stanley (cited in Caton-Thompson 1931, p. 201).

Iron working is one of the most significant advances in human technological development in prehistory. Over the millennia since its first appearance on the archaeological landscape, the making and use of the metal has impacted on humanity considerably and in the process helped to give the modern world its present character. However, the traditional concern in archaeology with searching for the earliest origins of cultures and civilisations, be it Mesopotamia, ancient Egypt or Great Zimbabwe (Arkell 1968, Caton-Thompson 1931, Connah 1987, Huffman 1978, Matthews 2003, Trigger 1969), has meant that little consideration has been given to issues such as modification once technologies were established. This is particularly relevant to the sub-Saharan region where there has been a tendency to assume that the production of iron remained static over time (Brown 1973, 1995, Cline 1937, Curtin *et al.* 1978, Pearce 1960, Rickard 1939, Stanley 1931a, Tylecote 1975). In contrast to this, even a cursory appraisal of African iron production reveals the existence of a variety of developments, such as slag tapping, the use of induced draught furnaces and improved organisation of production which increased output from the bloomery furnaces. This research was therefore initiated to tackle this issue of technological change and modification on the continent by considering iron production within the confines of pre-colonial Zimbabwe.

Figure 1 **Map of Africa showing the location of Zimbabwe**



Eurocentric perspectives on pre-colonial African Iron working

"...throughout the colonial period, sub-Saharan Africa was considered a backward continent on the receiving end of technological innovations" Holl (2000, p.6)

Indigenous iron production in the sub-continent has historically been seen indifferently and viewed as derivative in its origins and retarded in its development (Arkell 1968, Brown 1973, Cline 1937, Goody 1971, Gowland 1912, Rickard 1939).

In the first half of the twentieth century, this view was rooted in deep-seated racist and ethnocentric assumptions in which Africa was perceived as a "Dark Continent" where successive generations had lived in a stagnant way for millennia (Lane 2005). It was claimed that human societies had evolved through several stages from barbarism through savagery to civilisation (see Fagan 1997, O'Connor and Reid 2003, Robertshaw 1990). Whilst Europeans had reached the civilised stage with their level of technological sophistication, Africa was perceived to be still languishing below the development ladder at the savagery stage. It is therefore not surprising that explorers, travellers and colonialists who spread throughout the continent on the eve of colonisation argued that Africans occupied a stage in the evolutionary tree that Europeans had passed a thousand or more years ago (Hall 1987, p. 5). Consequently, African societies and technologies such as iron working were thought to be in a "deep and perpetual slumber" without any advancement (Brown 1973, p. 3, Curtin *et al.* 1978, Goody 1971) and their origins were explained in terms of diffusion from outside the continent. In this perspective, Egypt and Carthaginian settlements in North Africa were touted as centres of origin for the diffusion of sub-Saharan civilisations (Arkell 1968, Brown 1973, Cline 1937, Gowland 1912, Kense 1983, Pearce 1960). This is hardly surprising considering that early researchers were influenced by the pseudo-scientific theories of social evolutionism that believed in African incapacity, itself rooted in the colonial establishment (Chanaiwa 1973, Garlake 1982, Lane 2005, Robertshaw 1990).

Within this model of failing Africans, societal and technological developments which did exist were believed to have been introduced by civilised races such as the Hamites and Semites who had allegedly established their colonies across sub-Saharan Africa in deep antiquity. As O'Connor and Reid (2003) have posited, this Hamitic or Semitic myth was espoused by anthropologists such as Seligman (1930) who argued that these advanced races migrated from the Egyptian Nile into east and west Africa thus awakening the areas from their savagery. To the colonialists, these exotic myths provided a moral justification for colonial rule on the basis that the continent was once colonised by antecedent and progressive races (Garlake 1982, Lane 2005, Shepherd 2002, Ucko 1995).

Karl Mauch, a German explorer who visited Great Zimbabwe in the late 19th century, contended that it was the forgotten land of Ophir, a misconception that had been popularised by the Portuguese for a number of centuries (Garlake 1982, Hall 1987, Robertshaw 1990). Rhodes exploited these speculative ideas and employed "researchers" such as Theodore Bent to excavate the ruins and establish the exotic origin of the Zimbabwe civilisation. Bent's (1892) conclusions denied an African authorship to the site arguing that Africans neither had the capacity to build in stone nor to govern a state. This antiquated view was accepted by the majority of the settlers until the 1970s despite the existence of important scholarly researches by archaeologists such as McIver (1906), Caton-Thompson (1931), Robinson (1961a), Summers and Whitty (1961) and Garlake (1973) demonstrating the contrary. This entangling of the past with the politics of the day was vested in the colonial establishment throughout the 20th century across most of the continent, a phenomenon described by Trigger (1989) as the settler or colonialist paradigm in archaeological discourse. African technologies such as iron working were viewed with disdain by the early colonialists and antiquarians. The misconception that Africa has never invented anything but has only received from others was uncritically espoused at one time or the other by some researchers throughout the twentieth century and almost became dogma (Curtin *et al.* 1978, Lane 2005, Newton 1923). Thus until the second half of the twentieth century, this belief in antecedent races colonising Africa was dominant and led to the mistaken idea that human technological and cultural developments in the last 1000 years diffused from outside the continent via Egypt, after which they remained in inertia until the industrialisation introduced during colonial rule.

Amazingly, this negative perception of African societies and technologies contrasts markedly with the understanding of the preceding Stone Age times when Africa was perceived and depicted as the centre of technological developments. For instance, Louis Leakey's well informed studies at Stone Age sites in east Africa have since the early 1930s culminated in the establishment of stone tool sequences which manifested cultural and technological innovation in the region (Gowlett 1990). His work was paralleled by Goodwin's investigations in South Africa and Clark's in Zambia. For example, Leakey, Clark and Goodwin's lithic sequences demonstrated that the large bifaces characteristic of the Early Stone Age were replaced by smaller but regionally standardised implements typical of the Middle Stone Age (Bishop and Clark 1967, Goodwin 1935, Gowlett 1990). Subsequently, the emergence of new technological apparatus such as microlithic and composite tools in the years following 20 000 BP were hailed as significant innovations that differentiated Late Stone Age industries from their Middle Stone Age counterparts (Alimen 1957, Bishop and Clark 1967). Leakey celebrated his ability to reconstruct this technology through his knapping displays and butchery workshops, which he displayed across the continent.

In contrast to this, it was not explained why after being the centre of innovation for what has now been proven to be millions of years; the African continent should have suddenly become dormant in the last few millennia. Obviously, this denigration of Africa's recent past has got something to do with the negative perceptions and ethnocentric attitudes inherent in the colonial regimes seeking to justify colonialism (Chanaiwa 1973, Holl 1997, 2000, Robertshaw 1990, Shepherd 2002, Ucko 1987).

These eurocentric and ethnocentric views have also negatively influenced opinions on indigenous African technologies such as metallurgy. For example, it was argued that after receiving from others, traditional iron working remained static and unchanged for 2000 years with African master smelters in the late nineteenth century allegedly turning out much the same "clumsy" product (Curtin *et al.* 1978, p. 221) in the same way as their predecessors did a thousand or more years ago (Brown 1973, p. 4, 1995, p. 179). With this apparent absence of technological or cultural variability, there was no need to study African iron technology, as the appropriate focus of technological studies was held to be Europe and the Middle East, the proven theatres of innovation. In addition, African iron production was perceived to be a phenomenon of the ethnographic present to the extent that it could be used to interpret ancient iron working practices in Europe (Cline 1937) by highlighting the earliest stages in the process. Such formal analogies have been shown to be faulty because they do not take into account the broad cultural, geographical/environmental, chronological, and historical differences between the two continents (David and Kramer 2001, Lane 1994, 1996, Stahl 2005).

Another idea stemming out of these attitudes towards African technology was the misconception that indigenous African iron production was homogenous through time across the whole continent. This notion is often still implicit despite the fact that the rather sporadic and isolated studies that have been carried out so far seem to suggest some regional and chronological differences between different parts of the continent (David *et al.* 1989, Miller *et al.* 2001, Miller and van der Merwe 1994a, Schmidt 1997, 2001, van der Merwe 1980). Furthermore, Schmidt (2001) has argued that this homogenisation of African iron working in academic perception has stifled research that had the promise to unravel technological achievements potentially unique to the African continent. Ironically, the plethora of ethnographic studies carried out in southern and eastern Africa such as Schmidt's own work (1978) seem to unwittingly encourage this static view by reconstructing recent practices and using them to interpret the ancient past. In the 1960s and 70s, there was a general recognition among researchers that traditional African crafts were fast disappearing without trace. As a result countless rescue ethnographies were conducted to document processes before they vanished. Schmidt (1978) for instance conducted important ethnographic studies among the Haya and used the results of his work to interpret prehistoric iron working. By using such formal analogies, there is a danger that we unconsciously maintain the idea that indigenous iron technology was in stasis since its earliest manifestations in the archaeological record.

Clearly, there is ample evidence for considerable historical and regional variation if one considers the multiple furnace types that dot the archaeological landscape across the African continent (Cline 1937, Miller *et al.* 2001, Okafor 1993, Prendergast 1975, Schmidt 1997, Sutton 1985). From a technological viewpoint, furnaces were operated in different ways which suggest local developments chronologically and spatially. The Mafa smelters of northern Cameroon for instance produced cast iron from their furnaces, a product otherwise restricted to the blast furnace method introduced after colonisation (David *et al.* 1989). The Fipa of Tanzania employed both bellows driven and natural draught furnaces (Barndon 1996, 2004, Wemba-Rashid 1969). Okafor (1993) has reported on the existence of slag tapping in the Late Iron Age of Nsukka, eastern Nigeria, a technological development not documented in the preceding Early Iron Age of the region. This diversity in the practices of iron working across sub-Saharan Africa suggests that a diachronic study of iron production from the distant into the more recent past will unravel histories of technological developments that were designed to suit the available resources and prevailing social conditions. This demonstrates the importance of establishing local, regional and cultural traditions of smelting and smithing.

Ritual in African iron production has not been spared from derogatory and ethnocentric perceptions (Schmidt and Mapunda 1997). When he failed to understand the significance of symbolic dimensions of Venda iron workers in South Africa Beuster, (1889, cited in Rickard 1939, p. 89) posited that, "it was the ancient custom....for the smith to add human flesh to the ore in order that iron might make a good hoe, and if no flesh was available the smith sought for it among the dead". As an expert on Venda ethnography, Van Warmelo (1935) did not find any evidence for such cultural practices and thus such statements resonate very well with notions of a dark and savage Africa. Van Warmelo who was fluent in the Venda language and devoted almost his entire working career in exploring several issues of Venda culture and therefore it is highly unlikely that his informants could hide such important information from him (Miller *et al.* 2001). Even if the practice of using human anatomical parts as medicines in iron smelting was practised, it would therefore appear that the whole idea was exaggerated by Beuster, in so doing fulfilling stereotypical views of African society, culture and technology.

The socio-cultural contexts and the spatial organisation of iron working have also been perceived as timeless. Ethnographic accounts of the late 19th and early 20th century highlighted that iron smelting was considered to be a very dangerous activity which, coupled with the pervasive rituals that accompanied it, necessitated its location in secluded places where the process could not be observed by non-smelters (Bent 1892, Herbert 1993, Huffman 1993, 1996, Rickard 1939, Van der Merwe 1978). Based on these observations and nineteenth century ethnographies, archaeologists then argued that throughout the Iron Age iron smelting was conducted outside settlement areas. Thus, in his attempt to interpret the iron working remains from an archaeological site dating to AD 1200 in south-western Zimbabwe, van der Merwe (1978, p.101) argued that since iron smelting was *always* practised far away from villages in the ethnographic record, evidence of slag and tuyeres within habitation areas either meant that iron smelting and the site were not contemporary, or that the slag was a result of iron smithing. Certainly, such a perception contains some assumptions which should be disputed. In the first place, it erroneously presumes that iron working in the historical period was primordial yet such far fetched analogies have been repeatedly shown to be defective (see David and Kramer 2001). Above all, it ignores potential variations arising from contextual differences. Surprisingly, such thinking has influenced the perception of the way in which iron working was organised through time. Accordingly, this research critically examines assumptions that recent examples of the socio-spatial organisation of iron production represent unchanging continuities for the earliest periods of iron working on the continent.

Afrocentric perspectives on pre-colonial African Iron working

The emergence of radiocarbon dating in the 1950s led to the establishment of a deep antiquity for iron using agriculturalists in the sub-continent (Fagan 1997). In the absence of absolute methods of dating, it had been argued that the domestication of animals and metalworking were fairly recent, having been either obtained from Egypt or North Africa in the last 1000 years or so (Fagan 1997, Robertshaw 1990). Thus the great time depth which absolute dates created meant that the diffusionist explanations could be challenged as new discoveries were made that pre-dated the last one thousand years. Before the recognition of the limitations of ^{14}C on iron production episodes in the late 1980s, the dates falling to the second millennium BC were interpreted as evidence of independent invention of iron in Africa. For example, van Grunderbeek and Schmidt's dates of 1400 BC for the earliest practices of iron working in Rwanda and north-western Tanzania respectively seemed to support an independent innovation in the Great Lakes region of Africa although these data are no longer accepted.

Another important development contemporary with the radiocarbon revolution was the emergence of nationalist movements culminating in the attainment of independence by many African states. According to Garlake (1982) (see also Ucko 1995), in countries where the majority of the people are subjected to foreign rule, the study of the past often assumes a political dimension. Consequently, some archaeologists sought to overturn colonial myths such as the Hamitic theory and the settler paradigm that denied Africa a past and a sense of achievement by arguing that the continent was the centre of inventions (O'Connor and Reid 2003). A good example of this is the work of Cheikh Anta Diop who argued that ancient Egyptians were black whose civilisation influenced not only sub-Saharan Africa but Greece and Western Europe as well (Holl 1997). Diop's work was meant to demonstrate that Africa's inventive past was superior to that of other regions in the world such as Europe. Furthermore, Diop posited that iron working was indigenous to Egypt even though such claims were not often supported by the evidence on the ground.

Given the ideological interests of this afrocentric paradigm, archaeological research was focussed especially on the origins of agriculture, iron working, or the state rather than their development or regional chronology as it was believed that early dates would revise colonialist historiographies and turn them on their head (Thornton 1997, p. 56). The consequence of this obsession with revisionism and the over-concentration on origins was a failure to explore issues such as technological histories, variation within the technologies and the impact of such technologies in society. Thus in light of the above, it can be argued that the Afrocentric perspective on the African past had political goals of its own just as the settler paradigm which it sought to challenge. Both models of interpreting the African past should be discarded in favour of an approach that gives equal attention to origins and technological developments over time, elucidating issues such as long-term cultural change (Holl 2000) and how local technologies were connected to wider regional cultural and social institutions (Fagan 1997). However, in the context of the available studies on iron production in pre-colonial Africa, such a balanced approach is bedevilled by the fact that most studies have been sporadic, isolated and disconnected both geographically and thematically.

Clearly, there is a need to study iron working across space and time in order to understand the development of the technology. This demonstrates the need to construct coherent local technological histories; to accomplish this, I am going to consider iron production in Iron Age Zimbabwe.

Research Aims: An Outline

Using Zimbabwe as a case study, it is the aim of this research to:

- develop a long term perspective on pre-colonial iron production by investigating iron working in different historical periods and regions.
- reconstruct specific aspects of iron production such as furnace types, ores and symbolic dimensions of iron working. This will address questions such as what types of furnaces were utilised in the earliest smelting phases. Were they similar to those used in the later smelting phases, what types of ores were exploited by prehistoric peoples, did they develop particular extractive technologies to exploit certain ores, were the symbolic representations that have been noted in some recent smelting practices universally applicable and also characteristic of the earlier periods?

Ultimately, it will be possible to evaluate whether or not the inherent assumptions of stasis in the 2000 year history of iron production in southern Africa are valid. Unlike previous works that have focussed on isolated smelting and smithing incidents, this study will explore a number of related episodes to understand change and variation in technology across space and time. This will make it possible to situate technological developments once technologies had been established in several regions of Zimbabwe. Also, an approach which isolates the different aspects in the iron production cycle is limited in that it imposes arbitrary divisions which smiths and smelters of the past did not necessarily recognise. First of all, this study demands the use of the *chaîne opératoire* approach (see below) in understanding the specific phases in the production cycle. By its nature, *chaîne opératoire* research enables the reconstruction of all the processes involved from raw material procurement, the transformation of ores into cultural commodities through smelting and the use and discard of the material. Above all, such a framework facilitates the reconstruction of both the material and cultural dimensions of past technologies, achieving an anthropological view of technology (Childs 2000, Dobres 2000, Killick 1998, Lemonnier 1993, Pfaffenberger 1998). When considered chronologically such information can cast some light on the evolution of iron production methods in the past thus facilitating the creation of regional and local narratives of iron working practices spatially and over time. This research focuses on three strands of research: the ethnographic, archaeological and the archaeometallurgical studies of indigenous iron production to enable the long term study of iron working from recent times to the deeper past.

Perspectives on prehistoric iron production: the *chaîne opératoire* theoretical approach

Until recently, discussions of technology in western academic discourse disregarded the importance of socio-cultural factors in technological studies (Adams 1996, Appadurai 1986, Barndon 2004, 1996, Childs 1994, Childs and Killick 1993, Lemonnier 1986, Pfaffenberger 1988). Inspired by the mistaken belief that technology was the driving force in society, attention was therefore exclusively focussed on studying techniques of manufacture and understanding the technological hardware (Childs 1994, 2000, Herbert 1993, Lemonnier 1986). This led to the study of monolithic issues such as establishing typologies and tool function. In this dimension, archaeologists primarily concentrated on understanding archaeological contexts and the spread of new technologies, making culturally oriented technological studies very rare. This separation of material and cultural issues naturally propagated the genesis of alternative approaches that view technology as a socio-cultural construct (Adams 1996, Appadurai 1986, Barndon 2004, Childs 1991a, 2000, Dobres 2000, Haaland 2004, Haaland *et al.* 2002, Killick 2004a, Lechtman 1977, Pfaffenberger 1988). This change in orientation was precipitated by the *Anthropologie de Techniques* school of thought that emerged in France after the Second World War and much more recently by the anthropology of technology in Britain and North America. Mainly inspired by the writings of the French anthropologists Mauss and Leroi-Gourhan who argued that technology was a total social fact combining technical aspects and human behaviour, other researchers became more interested in exploring the human factor in technological studies (Dobres 2000).

According to Dobres (2000), the concept of *chaîne opératoire* can be traced from the writings of Leroi-Gourhan whose works perceived the importance of studying the technical sequences of material operations by which natural resources are acquired and transformed into cultural commodities. Leroi-Gourhan maintained that technology was embedded in other aspects of culture with the corollary that technological studies must address the social relations and choices and constraints encountered in artefact production and use. The notion has since been adopted by archaeologists such as Lechtman (1977) and Lemonnier (1986) who posited that social factors were not only as important as the technical aspects but also they determined which technologies were selected and utilised. Emerging from these perceptions was the realisation that concerns that were central to the production process, such as techniques of fabrication, relations of production, and symbolic aspects involved in artefact production could be reconstructed within a reasonable degree of accuracy. Nowadays the *chaîne opératoire* framework is popular with archaeologists working with technologies such as stone tools (Schlanger 1993); iron production (Childs 1998, 2000) and even pottery manufacture (van der Leeuw 1993) enabling researchers to investigate issues remote from the kilns and furnaces such as gender relations and the distribution of artefacts in society.

This general movement towards understanding socio-cultural factors in archaeological studies has also influenced researchers working on iron production on the African continent. However, it was archaeologists who were more anthropologically inclined, such as Schmidt (1978, 1983), who first combined anthropological and historical data in understanding pre-colonial technologies in east Africa. In his work, Schmidt (1978) documented both technical and socio-cultural factors associated with Bahaya iron working in north-eastern Tanzania. Although he did not refer to the term *chaîne opératoire* he argued that socio-cultural metaphors which were enshrined in rituals of transformation that accompanied the reduction of ores in the furnaces were an important part of the process yet they were disregarded by many researchers. Ever since then, a few researchers have studied the ideological and technological dimensions of African iron working. For example, van der Merwe and Avery (1987) documented the socio-cultural factors such as rituals and belief systems associated with iron production among the Chuli and Phoka of Malawi. The results of their work demonstrated that purely technical aspects, such as the failure of a smelt, were explained using factors such as sorcery and witchcraft, even if other reasons such as poor ores were involved. Accordingly, van der Merwe and Avery (1987) argued that these symbolic representations were central to the production of iron to the extent that ignoring them resulted in the reconstruction of an incomplete picture of the past.

In a series of papers, Childs (1991b, 1991c, 1994, 1998, 2000) utilised the *chaîne opératoire* or technological style approach effectively in understanding the socio-cultural dimensions of iron working in many sub-Saharan African communities. She contended that such an approach allows the simultaneous consideration of the material and symbolic activities involved from ore procurement through smelting to the use of the objects. In her study of Toro iron working in Uganda, Childs (2000) demonstrated that all the phases in iron production from mining through smelting to the forging of tools were highly ritualised processes. For example, the success of every smelt depended on both the careful selection of suitable raw materials and the strict observance of rituals and taboos such as sexual abstinence that were part of the craft (Childs 1998). Moreover, Toro iron working was a gendered craft with menstruating women being excluded in important phases such as smelting. Despite this, smelters acknowledged the importance of women in reproduction and in fertility for there was a conceptual link between iron smelting and human procreation. Thus Childs's work has shown the importance of culturally focussed theoretical approaches that jointly consider the repertoire of technological and socio-cultural factors involved in pre-colonial iron production. Also, by giving prominence not only to the technological aspects but also to the actions and choices that created the material culture, *chaîne opératoire* research moves the centre of attention to culture rather than the materials (Childs 1994, Dobres 2000, Lemonnier 1993, Pfaffenberger 1988).

This markedly contrasts with the technocentric approaches that separated human industry from the social relations that produce them and thus perceived human beings as peripheral in studying ancient technologies (Pfaffenberger 1988). The *chaîne opératoire* theoretical concept overcomes barriers imposed by an approach that has traditionally excluded symbolism, ritual and gender relations from the realm of technological studies (Childs 2000, Dobres 2000, Haaland *et al.* 2005, Reid and MacLean 1995). The major advantage of this approach in diachronic studies is that it considers all the phases involved in indigenous iron production from mining, through smelting and smithing to the use and discard of the artefacts. A comparison of the major phases of iron working over time generates valuable information on the evolution of technologies leading to the construction of histories of iron working. Such an approach has been long overdue in studies of iron technology in Zimbabwe much as elsewhere, where previous approaches either exclusively focused on the technical factors (Stanley 1929, 1931a, 1931b and Tylecote 1975) or the socio-cultural aspects (Barndon 2004, 1996, Bernhard 1962 and Collett 1993). Obviously, in order to understand the whole production cycle, consideration must be given to all characteristics whether cultural or technological (Dobres 2000, Lemonnier 1986).

It must be acknowledged that this is an initial attempt at defining the usefulness of the *chaîne opératoire* approach in a diachronic study and therefore the scope is necessarily huge. Zimbabwe is a very large country, in which iron smelting was practised for at least 1500 years (from c. AD 200 to 1900) (Miller 2001a). We can safely talk of tens of thousands if not hundreds of thousands of smelts taking place. This caveat was considered unimportant for the purposes of this research because it requires a wide focus so as to understand iron smelting in different regions and time periods and thus facilitate comparison between seemingly distinct traditions. Thus it is hoped that future studies will be much more focussed on individual sites and smelts, in so doing complement the broad picture depicted by this study.

Avenues for exploring an archaeometallurgical past

This section briefly discusses the methodology adopted in developing a long term perspective on iron production in Iron Age Zimbabwe. The Iron Age of Zimbabwe spans for over a millennium and half years. To construct local histories of iron working, an appropriate methodology must be developed to reflect this at intra-site and inter-site levels. This calls for the use of an inter-disciplinary approach that enables the investigation of iron working practices in different cultural periods. With its powerful investigative potential, an inter-disciplinary methodology combining ethnographic, archaeological and archaeometallurgical investigations of iron production remains was utilised to generate data for comparative purposes within a *chaîne opératoire* theoretical framework. The first strategy in developing a long term viewpoint on indigenous iron production was to evaluate the ethnographic record by considering iron working among the Njanja of Chikomba District, the Karanga of Shurugwi and the Kalanga people of south-western Zimbabwe **(see Fig. 8)**. For the Njanja, oral interviews were conducted among the Ranga and Kwenda people known to have practiced iron smelting in the historical period (Franklin 1945, Mackenzie 1974a, Posselt 1924, 1926). The oral data were supplemented and thus counter-balanced by documentary research on Njanja iron production.

Archival information was the major source for reconstructing iron working among the selected Kalanga and Karanga groups. There exists a fair amount of data recorded by various people on the Kalanga of the Matopos (Cooke 1959, 1966, Hatton 1967) and on the Karanga of Shurugwi (Prendergast 1972). However, data from oral informants and that from archives can be affected by factors such as selectivity and biases. This demands a rigorous assessment and careful use of these sources in order to achieve a fuller appreciation of the past (Finnegan 1970, Vansina 1985). Childs (2000) has profitably employed such an approach with remarkable distinction in salvaging the knowledge of iron working among the Toro of Uganda. She used early twentieth century ethnographic details by Roscoe to cross-check the veracity of the claims made by her chief informant demonstrating that valuable data can be obtained by careful source evaluation and criticism.

A comparative study can reveal discrepancies and similarities in the practice of iron working amongst the selected Shona groups in the late 19th and early 20th centuries. Arguably, such an exercise generates information about variation in the short term. However, to develop a deep time view on indigenous iron working we need to consider archaeological evidence. The archaeological record offers a platform on which to explore the patterns of prehistoric iron production in the Iron Age of Zimbabwe during which we also presume that change took place. Several iron production sites belonging to the Early and Late Iron Age were selected in northern and eastern Zimbabwe to conduct further and detailed studies of iron working. Excavations and controlled surface collections of iron working debris were carried out at these sites to retrieve material for further analysis in the laboratory. The iron working remains recovered from the excavations were subjected to archaeometallurgical studies in the laboratory to gain specific technical data relating to the different phases in the iron production cycle.

The integration of these three research strategies provides a holistic understanding of the craft and its continuity and variability over time, illuminating our perception of change spatially and diachronically by generating well-informed interpretive and analytical methodologies. Miller *et al.* (1995) have shown the value of an approach combining archaeology with archaeometallurgy and ethnography in understanding iron working among the mid-19th century Hurutse people in the Limpopo Province of South Africa. Thus, rather than being a mish-mash of categories of evidence from different sources, there is no doubt that the approach adopted in this study unequivocally demonstrates the theoretical, methodological and interpretative value of combining seemingly disparate methods of study, namely the ethnographic, the archaeological and the metallurgical.

Summary

Most early studies on iron production in sub-Saharan Africa were constrained by the misconception that indigenous iron working remained unchanged since its emergence sometime in the last two millennia. This stemmed from the negative attitudes that had their roots in ethnocentric and eurocentric ideas espoused by early researchers such as Cline (1937) and was not helped much by the continuing focus of Afrocentric research on identifying the earliest evidence for iron metallurgy in Africa. With the length of the history of iron working in sub-Saharan Africa, there is a clear possibility that new technologies such as the use of slag pit furnaces developed over time. This demonstrates the need to develop a long term view of African iron production, exploring issues such as change, spatially and temporarily. In order to achieve this, long held beliefs must be abandoned in recognition of new evidence. There are strong indicators for change in African iron working if the variability in the types of furnaces which were operated in different regions and periods are considered. It is thus hoped that reconstructions that were coloured by the prejudice of early researchers will be replaced by studies that place pre-colonial African iron production in its full social and cultural context, highlighting technological continuities and discontinuities over time. The next pertinent stage in this study therefore is to give an overview of the technology and socio-cultural context of iron production and the themes that have dominated studies on iron working in the sub-continent, which is the focus of Chapter Two. Chapter Three presents a review of the major issues that have been engaged in studies of pre-colonial iron production by narrowing the focus to Zimbabwe. Chapter Four considers iron production among selected proto-historic and historic groups in Zimbabwe. Archaeological studies of iron production are dealt with in Chapters Five and Six with Chapter Seven being devoted to archaeometallurgical investigations. The discussion and interpretation of metallurgical work is given in Chapter Eight while Chapter Nine summarises the information from all the research strategies and suggests potential future avenues of research on iron production.

Chapter Two: Issues in African Iron Production

Introduction

This chapter begins with an outline of the basic technological requirements for iron production, before explaining the history of research and the themes that have dominated iron working studies, namely origins, ethnoarchaeology and technology. It ends by explaining ways by which a more integrated investigation of iron smelting may be pursued to generate technological histories.

The technology of early iron production was universally through the direct process in which iron ore was reduced to metallic iron by carbon monoxide gas to form a solid but spongy mass of metal bloom and slag by-products (Buchwald 2005, Craddock 1995, Joosten 2004, Miller 2001a, Miller and van der Merwe 1994a, Tylecote 1976, Van der Merwe 1980). It comprised two separate and successive operations: smelting to extract the metal from the ore and smithing to refine the bloom and to forge tools (Brown 1995, Killick and Gordon 1988, Miller 1997, 2002, Pleiner 2000). The bloom from the furnaces contained impurities and therefore had to be refined by smithing to consolidate it into usable iron. Although a wide range of methods of producing iron using the direct method existed in pre-colonial Africa, they all thrived on the same fundamental metallurgical principles utilising similar raw materials for their success. The needs essential for the successful smelting of iron are ores, carbon, suitable clay for making combustion chambers, tuyeres/blowpipes and air. The addition of heat to these variables during smelting initiated reactions which led to the eventual production of the metal bloom. Overall, the smelting and smithing of iron resulted in a variety of residues such as slag, collapsed furnace fragments, hammerscale and finished products.

These purely material elements of indigenous iron production were often accompanied by a series of non-technical socio-cultural rites such as rituals and taboos (Barndon 2004, Childs and Herbert 2005, Childs 1991a, Collett 1993, de Barros 2000, Herbert 1993). Indeed, these so-called magical aspects and the relations of production between different peoples gave structure to indigenous iron working. There were sacrifices and rituals such as slaughtering animals and practising sexual abstinence that were observed and also formed a complex web constituting most of pre-colonial African iron working. The beliefs in magic and fear of witchcraft reflected the general societal perceptions and worldviews of smelting and non-smelting groups alike (Bourdillon 1976). When juxtaposed with the technical needs for iron working, the pervasive nature of fertility symbolism and other rituals demonstrates that a complete smelt was the product of the interaction between cultural choices and representations, the skill of the smelters and smiths and technological parameters such as the quality of the ore. Obviously, considering the archaeological contexts from which the finds were retrieved is crucial and analyses of the cultural aspects of the production process such as furnaces, decorations, and spatial arrangements, and even shape and function of finished objects helps to shed more light on the development of iron production over time.

Many ferro-metallurgical remains were recovered in contexts which suggest their use in domestic settings as well as in religious and trade networks. There is no doubt that once established, iron played an important role in making utilitarian tools and weapons and non-utilitarian jewellery items (de Barros 2000, Holl 2000, Miller 2002). The beads and bracelets recovered from Nqoma and Divuyu in Botswana were used for personal adornment (Miller and van der Merwe 1994b) while ceremonial axes from Sanga, DRC were used as expressive items in maintaining kingship and negotiating gender and social relations (de Maret 1985, 1999). It has been argued that the increased availability of tools such as hoes and axes, used for clearing the land, led to increased food production and subsequent population increases (de Barros 1986, Haaland 1980, 1985).

With this currency that the metal appears to have had in prehistory, indigenous iron production in Africa has been the focus of considerable scholarship both by peripatetic scholars and by professional archaeologists and ethnographers since the closing decades of the 19th century. Over time, old opinions and views regarding the technology, adoption, use and impact of metallurgy in African societies have been revised with the proliferation of data from securely dated archaeological contexts (de Barros 2000, Holl 2000, Miller 2002, Woodhouse 1998). However, most of the early studies on indigenous African iron working were both geographically and thematically isolated. Whilst these studies are a rich database on which to study prehistoric iron working, there is need for a more integrated research in order to understand how iron was produced and used in different societies and its place in extant societies.

The technological variables of indigenous iron smelting

Ores

Ores are rocks whose metallic content is sufficient to permit the economic extraction of metal. Iron is one of the most abundant elements of the earth's crust, and iron ore deposits occur in the form of oxides and hydroxides with only low levels of other compounds (Pleiner 2000, Rostoker and Bronson 1991). In sub-Saharan Africa, smelters utilised a wide diversity of iron ores. Generally, the ores that were exploited varied from locality to locality depending on the local geology and the cultural choices made by the smelters. Such ores range from the lean/low grade laterite ores of the Chewa of Malawi (Killick 1990) to the rich magnetite used by the BaPhalaborwa people of South Africa (Miller *et al.* 2001). Other common examples of ores that were smelted in prehistory include magnetite sand exploited by some West African societies such as the Yoruba of Modakeke, Nigeria (Ige and Rehren 2003) and haematite smelted by the Lemba and Karanga living around Mt Buhwa in Zimbabwe (van der Merwe 1978). This diversity of ores exploited in the past also implies that prehistoric and proto-historic peoples developed different types of smelting technologies suitable for extracting locally available ores. The low iron content (between 45 and 50% wt FeO) of the Chewa ores meant that they had a rather high content of gangue material, not all of which reacted during smelting requiring a low temperature to reduce them (Killick 1990, Killick and Gordon 1988). In contrast, high grade ores had a much smaller proportion of siliceous materials to the extent of requiring the addition of fluxing material. Smelters from the BaPhalaborwa region consciously added sand as flux to facilitate the slag/metal separation in the furnaces as well as to lower the melting temperatures of the impurities (Miller *et al.* 2001, van der Merwe and Scully 1971). This deliberate addition of sand as flux is but one example of how early smelters made innovations to extract iron from different kinds of ores. The variety of ores utilised across Africa shows that all types of ores whether rich or lean may have been exploited at one time or another, underlining the need as well as potential for constant development and adaptation of the technology.

There is an element of conservatism and or tradition where people made an extra effort to get the ore they were used to, and not to adapt their technology to different ores. For instance, generations of the BaPhalaborwa people in northern South Africa have historically been linked with the iron ore from Lolwe Hill (Miller *et al.* 2001). Open cast mining at varying levels of intensity was the predominant method of ore extraction. Upon being collected, the ore was crushed into small pieces and sometimes the gangue materials adhering to the ore were removed thus improving the quality of the ore, a process known as beneficiation. The ore was then dried, ready for the reduction process in a furnace. The differences between different ores were further stimulus/need to adopt new technologies to given parameters. For example, not only did the quantity of gangue but also its nature demanded adaptation as seen in the case of Chewa of Malawi who used a two stage process and the BaPhalaborwa who used a flux.

The extraction of iron ore was in some societies subject to rituals and taboos. Amongst the Toro people of Uganda for example, menstruating women could neither mine the ore nor touch it at any stage in the smelting process. Their involvement allegedly led to the poisoning of the smelts and culminated in the smelt's failure (Childs 1998, 2000). However, such practices were not applicable to all societies. For instance, among the Bassar of Togo, women took part in the mining and drying of ore (de Barros 1988). Another issue of interest is the fact that in some areas ownership or control of the mines or the source of the ores enhanced the status of particular groups of people. Among the Toro of Uganda, the mine owner got royalties from other people exploiting his mine (Childs 1998). However, among some societies in Sudan and Ethiopia, the low status accorded iron workers meant that miners did not have any influence in society (Haaland 2004, Haaland *et al.* 2005).

Charcoal

Charcoal was one of the most essential ingredients utilised in pre-colonial iron production. Historically, indigenous iron production has been exclusively associated with the use of charcoal as the principal source of fuel to drive the reactions in the furnaces (Cline 1937, Miller 1997, Miller and van der Merwe 1994a, Schmidt 1997). As a fuel, it was consumed in considerable quantities for preheating the furnaces, the subsequent smelting, the refining process and the fashioning of finished goods. Charcoal provided the heat needed for the reactions in the furnace to be initiated whilst at the same time acting as a reductant (Miller 1997). It was produced through the controlled and incomplete burning of large stacks of wood. As a fuel, charcoal is chemically pure and devoid of impurities such as sulphur which would have compromised the quality of the end product (Killick and Gordon 1988, Rostoker and Bronson 1991, Schmidt 1997).

The selection of tree species for charcoal production required great care and knowledge as charcoal from different tree species possess distinct properties (Joosten 2004, Mapunda 1995, 2003, Miller and Killick 2004). Some tree species burn quickly producing a lot of ash, characteristics that are not desirable in the typical smelting process. Generally, hard woods which had a high energy output were preferred by smelters and smiths (when located in the vicinity of iron smelting areas). A link has been demonstrated between the level of wood consumption for charcoal production and deforestation for it has been proposed that sustained iron working activities led to deforestation in areas such as the Sudan and Ghana (Haaland 1985, 1980). Furthermore, Schmidt (1997) discusses the diachronic change in tree species used by Bahaya smelters and smiths which affords an interesting insight into the patterns of woodland management. Potentially, the selection and use of certain trees at certain times would have given other species time to regenerate thus minimising the impact of continued iron working activities over time. Mapunda (2003) suggests that iron smelting in western Tanzania was not responsible for vegetation change, despite the fragility of the local ecology.

Clay

Clay was used to make the combustion chambers or the furnaces and the blow pipes which carried the air to the heart of the furnace. It had to be sufficiently heat resistant to maintain the mechanical integrity of the furnace and insulating enough to keep the heat loss through the furnace walls to a minimum. Depending on the nature of the ore, the clay may have to contribute a fluxing component to facilitate the smelt. Most areas have suitable clays whose properties can be modified as required by tempering or mixing. In some cases suitable clays had to be obtained from distant localities. This was not an all pervading practice for in societies such as those studied by Haaland in the Sudan the clays were tempered to improve their quality. At times two different clays were mixed to get the desired ends (Childs 1989). In the Great Lakes region of Africa, the clays that were used to make furnaces were occasionally different from those that were used for tuyeres. In the western parts of Buganda for example, tuyeres were made of kaolin while the furnace superstructure was made of ordinary clay (Humphris 2004). However, in other smelting societies nearby both the furnace and tuyeres were made using the same type of swamp clay. Apart from making the combustion vessels, the clay sometimes played a very significant part in the chemistry of the furnace by reacting with the iron oxide (acting as a flux) to help in the formation of a free running slag (Miller and Killick 2004). Thus smelters had to strike a balance between clays that would withstand high temperatures yet which would slowly corrode to help in the slag metal separation (Bachmann 1982, Bayley *et al.* 2001, Crew 1998, Rostoker and Bronson 1991).

Furnaces

A wide variety of furnaces have been used to smelt the equally diverse ore types that are abundant in the sub-Saharan African region. Fundamentally, all furnaces operated on the same principle of directly reducing the metal from the ore. One of the most important tasks of the furnaces irrespective of their design was to generate high temperatures while at the same time maintaining reducing conditions (Joosten 2004, Miller and Killick 2004, Rostoker and Bronson 1991, Schmidt 1997). Iron smelting furnaces in sub-Saharan Africa came in many forms: bowl furnaces consisting of a pit and very low wall above the ground, low shaft furnaces which were either slag tapping or non-slag tapping and very large shaft furnaces which were powered by natural draught using the principle of convection (van der Merwe 1980). These furnace types had different diameters, with the natural draught furnaces being very large while the low shaft and bowl furnaces were comparatively small. However, one cannot rule out the existence of very large furnaces which were bellows driven and more research could shed more light on this.

Efforts to study the distribution of furnace types across space and time have provided frustratingly little information, as furnaces of different designs were simultaneously operated by different groups of people (Cline 1937, Miller and van der Merwe 1994a, Pole 1985, Sutton 1985, van der Merwe 1980). For example, among the Phoka of Malawi, the smelters initially employed natural draught furnaces and subsequently processed the partially reduced products in bellows driven shaft furnaces, with no provision for slag tapping. The two types of furnaces were different in terms of size, method of operation and output (van der Merwe and Avery 1987). Although less labour intensive in terms of the actual smelting, natural draught furnaces are known to have consumed huge quantities of charcoal with devastating effects to the environment (Haaland 1980, 1985). In addition, they were time consuming since it took not less than three days to produce iron in them (Rehder 2000, 1990, Killick 1991a, 2004b). Comparatively, the bellows driven furnaces are very labour intensive in pumping the bellows though it took about three to four hours to successfully smelt iron in them. Because natural draught furnaces are very large, it has been assumed that their output was correspondingly higher than that obtained from other furnace types (de Barros 1988). For instance, the huge natural draught furnaces used by the Bassari of Togo were well suited for their large scale iron production which catered for a very wide region in West Africa. On the other hand, there are also some low shaft furnaces particularly those which were slag tapping which produced a high output. By successively using natural draught and bellows operated furnaces, Phoka smelters (Malawi) as well as those from Ufipa (Tanzania) exploited the strengths of the two furnace types mentioned earlier (Barndon 2004, Killick 1991a, Gordon and Killick 1993). These Bassari, Malawian, and Tanzanian case studies show that whether to use a low shaft furnace or a huge natural draught furnace was thus partly dependent on factors such as cultural preferences, the nature of the ore and the scale of production.

A study of the evolution of smelting techniques over time shows that the inception of slag tapping furnaces was an important technological development (Buchwald 2005, Pleiner 2000). This is because the intentional removal of slag from the furnaces during smelting enables the process to be conducted continuously without being clogged by the slag. Okafor (1993) has argued that the advent of slag tapping furnaces in the Late Iron Age of Nigeria increased the output because continuous smelting meant that the size of the bloom was big. In addition, smelters did not have to worry about issues such as reheating the furnace upon termination of the first smelt. Okafor's findings are corroborated by observations made by Pleiner (2000) whose decades of research in the Iron Age of Europe illustrated the link between slag tapping and enhanced output in the early bloomery process. Equally, mineralogical and chemical analyses of slag from a Roman site carried out by Morton and Wingrove (1972) also demonstrated that when compared to non-tapped slags, tapped ones contained lower levels of residual iron oxide, an indication that the slag metal separation was more complete in the latter than in the former. This shows that smelters made modifications once technologies were established.

Air

The air for burning the charcoal in the furnaces was provided either by pumping it through the air pipes using bellows (forced draft furnaces) or letting the furnace act as a chimney, drawing the air naturally through the combustion zone (natural draught furnaces) (Cline 1937, Kense 1983, Miller 1997, Rickard 1939, Stanley 1931a, Tylecote 1975, van der Merwe 1980). The furnaces used by the Fipa of Tanzania used induced draught just as those of the Chewa of northern Zambia (Mapunda 2003, Schmidt 1997, van der Merwe 1980). In the forced draught furnaces, the air flow was generated by pumping bellows of different designs. Bag and pot bellows were the most commonly used types across the sub-continent. The bag bellows were usually made of animal skin while in the pot bellows an animal skin diaphragm was attached on the mouth of a pot made of clay or wood. These types of bellows are distributed across most of central, west and east Africa while in southern Africa most of the evidence points to the use of bag bellows. It has been argued that bag bellows evolved out of the pot bellows since they generated a greater volume of air (Mackenzie 1974b) but whether the variation in the use of the two types of bellows was determined by cultural choices or functional preferences is not known. The making of bellows was a gendered occupation to the extent that in some societies it was the preserve of experienced males only. However, among the societies of the Highlands of Ethiopia, the making of pots for bellows was done by the wife of the head smelter who was herself a potter (Haaland 2004, Haaland *et al.* 2005).

The chemistry of the process

When all the ingredients necessary for smelting were gathered, the process of smelting was initiated, that is the chemical reduction of iron ore by carbon monoxide. After the furnace was preheated, the charge, consisting of alternating layers of ore and charcoal, was added into the furnace (Franklin 1945, Haaland 2004, Miller 1997). The bellows or natural draught provided the air that was essential for achieving the high temperatures required for successful smelting to occur. The process of smelting got underway at the top of the furnace when the charge was added and was complete by the time a given unit of charge reached the bottom of the furnace. Where no prior roasting of the ore was done, this took place at the top of the furnace where conditions were oxidising and the temperatures were in the range of 500° Celsius (Bayley *et al.* 2001). Apart from driving off the moisture from the ore, the breaking down of compounds in the ore caused micro-cracking in the ore lumps which made it more porous and amenable to the reduction process (Buchwald 2005, Rostoker and Bronson 1991). This facilitated reduction by allowing reducing gases to move easily to penetrate the ore. As the charge moved down the furnace it experienced a series of chemical reactions until it entered the reduction zone where the oxide turned into metallic iron (see the equations below). The separation of metal and oxygen from the ore was accomplished by a reagent with a great affinity for oxygen i.e. carbon monoxide, a product of incomplete combustion of carbon. By manipulating the air input and ratio of ore to fuel the head smelter could control the balance of gases and the temperature in the furnace thus exercising control over the quality of the bloom (Miller 1997). The two fundamental chemical reactions that took place during iron smelting are the reduction of iron oxide to form metallic iron and the formation of a liquid slag. As the ore drifted down through the furnace, it was reduced in the following sequence of reactions:

haematite $\longrightarrow$ magnetite $\longrightarrow$ wuestite $\longrightarrow$ metallic iron

$$3Fe_2O_3 + CO \longrightarrow 2Fe_3O_4 + CO_2$$

$$Fe_3O_4 + CO \longrightarrow 3FeO + CO_2$$

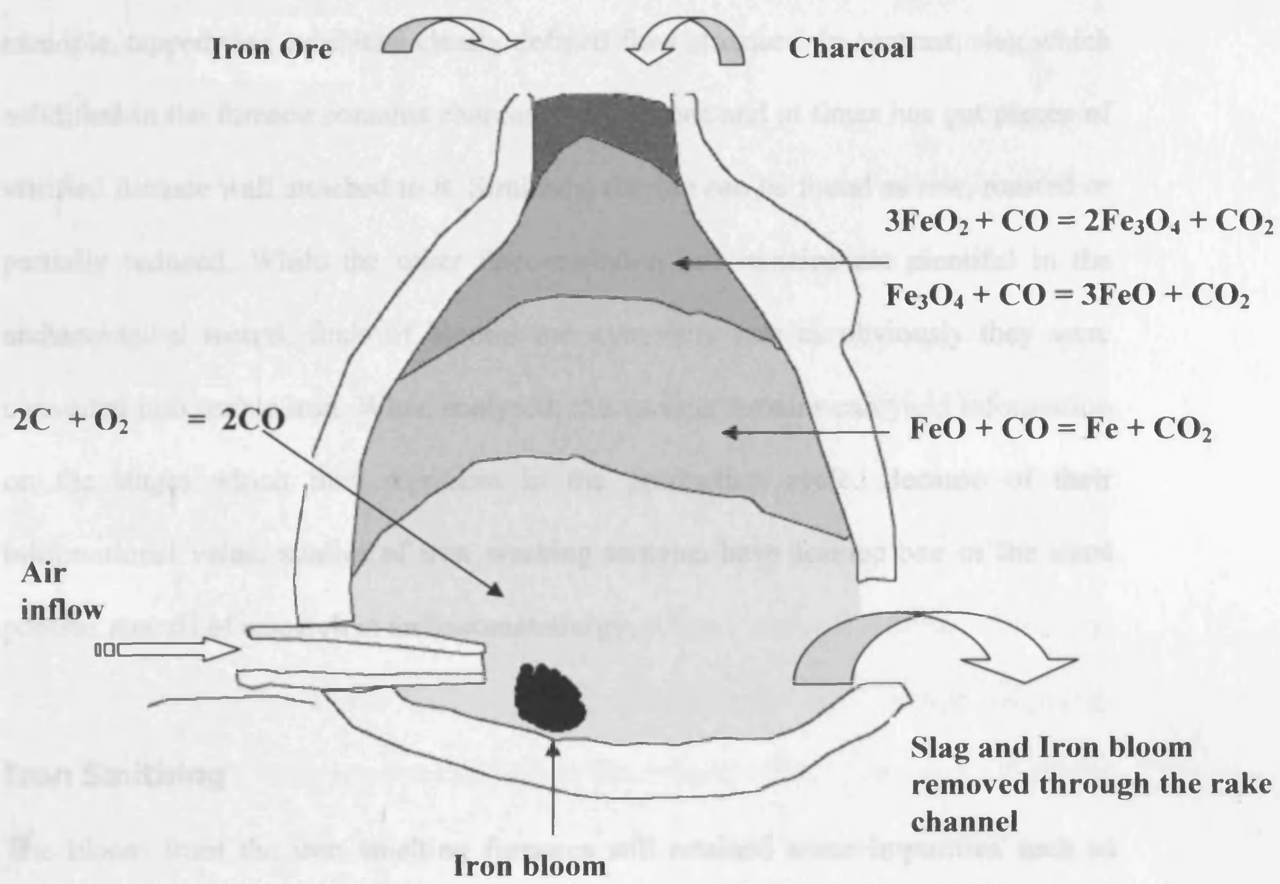
$$FeO + CO \longrightarrow Fe\ (metal) + CO_2$$

However, the ore contained gangue material (non-metallic components of the ore) which had to be removed as well. In order to achieve this, a slag had to form by reacting with some of the iron oxide through the following reaction

$$2FeO + SiO_2 \longrightarrow Fe_2SiO_4 \text{ (fayalite)}$$

The liquid slag dripped off to the bottom of the furnace where it solidified and was removed upon terminating the smelt or it was tapped into a pit located below or outside the furnace leaving the iron bloom (Joosten 2004, Miller 1997). The formation of the slag was a very crucial and indispensable part of the extractive process. In addition to being a depository of the impurities, the slag was necessary in the formation of the bloom by preventing re-oxidation of the iron particles as they drifted down the furnace to the hottest zone, in front of the tuyeres.

Figure 2 Diagrammatic representation of a typical Shona non-slag tapping iron smelting furnace. Note that the diagram summarises all the reactions up to the removal of the slag and the bloom through the rake channel.



After several hours of smelting, the process was terminated. The product or bloom was both internally heterogeneous and variable from furnace to furnace, varying from soft malleable iron to high carbon steel and cast iron depending on the conditions of the smelt (Killick and Gordon 1988, Pleiner 2000, Rostoker and Bronson 1991). Because the metal bloom contained occluded slag, it had to be refined through primary smithing, with the intermediate ingot or billet being subsequently converted into different tools and objects.

Upon termination, the process of smelting left residues ranging from more or less intact furnaces, broken tuyeres, slag, remains of ore, charcoal and bloom. Different kinds of slags exhibit different morphological characteristics which can aid the definition of the processes which gave birth to them (Miller and Killick 2004). For example, tapped slag exhibits a clearly defined flow structure. In contrast, slag which solidified in the furnace contains charcoal impressions and at times has got pieces of vitrified furnace wall attached to it. Similarly, the ore can be found as raw, roasted or partially reduced. While the other ferro-metallurgical remains are plentiful in the archaeological record, finds of blooms are extremely rare as obviously they were converted into usable iron. When analysed, the various remains can yield information on the stages which they represent in the production cycle. Because of their informational value, studies of iron working remains have formed one of the most popular strands of research in archaeometallurgy.

Iron Smithing

The bloom from the iron smelting furnaces still retained some impurities such as charcoal and slag inclusions and therefore had to be refined through smithing (Bayley *et al.* 2001). Smithing was done in two phases, primary and secondary smithing. Primary smithing involved the repeated hammering of the mass of bloom in a forge to expel the included slag and charcoal thus freeing the metal from inclusions and producing a dense ingot or billet (Crew 1998, Miller and Killick 2004, Pleiner 2000). The tools of the smiths included anvils and hammers which in most pre-colonial African societies were made of either wood or hard igneous rocks. Primary smithing was sometimes conducted in the vicinity of the smelting furnaces to take advantage of the residual heat. After this refining exercise, the ingot was then hot and cold worked during the process of secondary smithing and forged into a wide inventory of objects for local consumption or for trade (Miller 1997, 2002).

The process of smithing left residues such as slags, prills, collapsed hearths, hammerscale, charcoal and finished products. Slags diagnostic of iron smithing take two main forms: bulk slags (smithing hearth bottoms and ordinary looking slag) and micro-slags (hammerscale and prills) (Bachmann 1982, Bayley *et al.* 2001, Greenfield and Miller 2004). Of the bulk slags, the smithing hearth bottom (SHB) is the one least likely to be confused with smelting slags (Greenfield and Miller 2004, Serneels and Perret 2003). The SHBs formed as a result of high-temperature reactions between the iron, hammerscale and silica from either a clay furnace lining or the silica flux used by the smith (Bayley *et al.* 2001, Joosten 2004, Miller and Killick 2004). The combination of materials (oxides and silicates) produced during the smithing exercise dripped down into the hearth base where it accumulated in layers giving the whole pool of slag a bun shape upon solidification (Bachmann 1982, Greenfield and Miller 2004, Miller and Killick 2004, Serneels and Perret 2003). While the bun shaped smithing hearth bottoms are clearly defined in the European case, in Africa they have not been subject to many studies. As a result very little is known about them. The other type of smithing slag (ordinary looking slag produced during primary smithing) is hardly distinguishable from that produced during smelting and is thus very difficult to identify in the archaeological record (Bachmann 1982, Bayley *et al.* 2001, Serneels and Perret 2003). Owing to this and a variety of other factors, the process of smithing has not been well studied in sub-Saharan Africa, leaving a major gap in our knowledge of the *chaîne opératoire* of the process.

History of investigations

The advent of colonialism witnessed the beginning of studies on indigenous African iron production by archaeologists and ethnographers. Like the development of general archaeological studies in Africa, the study of iron production has passed through several distinct stages which mirrored the specific interests of the researchers who were often influenced by the dominant attitudes and ideas of the day (Holl 2000, Kense and Okoro 1993, Killick 2004c, Miller and van der Merwe 1994a). These phases can be tentatively divided chronologically into the late 19th century to the 1920s, the 1930s to the 1970s and the 1980s to the present. Initial research in the first phase tended to focus on observations of what was believed to be remnants of the earliest iron smelting techniques that were long extinct in Europe (Gowland 1912, Kense 1983, Rickard 1939). The second stage was characterised by detailed studies of indigenous iron working by professional ethnographers and archaeologists while the last stage saw a gradual increase in studies that sought to reconstruct the socio-cultural representations of iron working.

In the initial period of contact between Africans and Europeans, the latter often recorded many aspects of the former's culture. To this generalisation, African iron working is no exception. Early European travellers and missionaries who were resident at the courts of African kings sometimes recorded vital information on iron smelting and smithing (de Barros 1988, Miller *et al.* 1995). Such works were not academic studies but their importance lies in the fact that they have documented African iron working during the initial contact period. For example, the missionary John Campbell based at Kaditswene, the BaHurutse capital in north-western South Africa observed and recorded crucial elements of indigenous iron working such as the types of furnaces, the gendering of the craft and the spatiality of iron working in the 1820s. In West Africa, Mungo Park reported on iron working by the indigenous people of the Lagos hinterland in Nigeria (Bellamy and Harbourd 1904, Rickard 1939) while Gowland (1912) documented the different types of furnaces and compared them with those of the European Iron Age. However, ethnohistorical sources must not be considered at face value for they sometimes contain explicit and or implicit omissions or modifications of crucial information.

After the establishment of colonial rule and its administrative structures, professional ethnographers and archaeologists from Europe and North America took a keen interest in studying and recording the material culture of the colonised populations. For example, the ethnographer Roscoe (1923) recorded the process of iron working among the Batoro and Banyoro people of Uganda including the organisation of production, and rituals and taboos involved in the process. This phase saw an increased emphasis upon the ethnographic study of iron production with more careful examination of both the construction of furnaces and the other components of the iron working cycle. On his part, Cline (1937) summarised the known ethnographic data for smelting operations during his time, including the selection and preparation of ores, construction of the smelting furnaces, the type of bellows employed and the time involved in the actual smelting process. Like Gowland (1912), Cline classified the African iron smelting furnaces whether archaeological or ethnographic using a framework established for the classification of European furnaces. African furnaces were thus classified into simple bowl furnaces which were the earliest, followed by shaft furnaces which were non-slag tapping and then slag tapping with the latest furnace type being those that used self induced air flow for smelting. However, due to the complexities of the different furnace types that were operated in pre-colonial Africa, such a classificatory scheme has been shown to be rather simplistic and above all it does not reflect the true picture that existed in prehistory (Sutton 1985). Also, Cline's studies were largely cultural in nature with little information on metallurgical parameters such as the quality of the ores used and the iron produced from the many furnaces dotted across the sub-Saharan latitudes. Such information would have enriched our understanding of the entire production process. As the data gathered by these early ethnographers tended to be sporadic and unbalanced in both geographical coverage and detail, this perspective led to erroneous conclusions as to the antiquity and importance of African metallurgy (Kense 1983, Kense and Okoro 1993). This is because the early researchers such as Cline reinforced assumptions that pre-colonial African iron working was in the ethnographic present. Despite containing the above mentioned caveats, these early ethnographies form an invaluable database on which to study iron production on the continent, and subsequent studies on iron working in pre-colonial Africa have more or less made reference to them.

From the 1950s, through to the 1970s, historians of technology began investigating prehistoric iron working remains from a metallurgical point of view that added little towards the understanding of the societies concerned (Holl 2000, Prendergast 1974). The relics of iron pyrotechnology such as slag, furnace remains and ores from several sites across the continent were taken and scientifically investigated in many laboratories outside Africa. It has been argued that the furnaces were not particularly efficient in terms of iron extraction for example, yet they were capable of producing iron from a diversity of ores, some of which could be too lean in iron or too small in size to warrant modern day processing (Killick 1990, Killick and Gordon 1988, Tylecote 1976, Tylecote 1975). However, little attempt was made during this period to study the cultural dimensions associated with prehistoric African iron production, which led to the reconstruction of an incomplete picture of the past.

By the late 1960s, the term Iron Age in sub-Saharan Africa became associated with a cultural package comprising the making and use of pottery, metallurgy, settled life, and agriculture (Phillipson 1977, 1985, Soper 1971). As a result of such a broad distinction, Iron Age studies encompassed a wide range of research interests of which only a single strand was concerned with ferro-metallurgical evidence. The study of iron working remains was mainly restricted to the general reporting of the existence of artefacts such as iron slag, tuyeres and furnace remains which were all seen as part of the broad Iron Age culture (Prendergast 1974). For many parts of Africa, little was known of the techniques of iron smelting employed by prehistoric groups. This is because iron processing remains were not investigated with metallurgical considerations in mind, and much potentially useful information such as the contexts of iron working episodes has been lost due to lack of realisation of the information that can be obtained in this way (Prendergast 1974). The other limitation was that most archaeological investigations in the 1950s and 1960s were concerned with issues such as assigning a particular technology to the established ethnographic classification and determining its place within a pre-defined chronological and typological scheme (Bernhard 1962, Kense 1983). These studies were largely cultural in nature and no effort was made to understand the metallurgical aspects of prehistoric iron working by archaeologists in this period even if the research was carried out by European and North American colleagues who could have organised access to the necessary analytical equipment. The 1980s and 1990s specifically saw an upsurge in studies that sought to reconstruct the socio-cultural dimensions such as the symbolism and rituals associated with iron working (Barndon 2004, 1996, Childs 1991a, Collett 1993). However, the techno-centred and the culturally oriented (anthropological) studies were often done at the same time, but largely unaware of each other's potential and methodologies.

Origins of African Metallurgy

Africa's metallurgical past is intriguing in that it deviates from the picture in Eurasia where the working of stone was followed by the exploitation of the so-called less complicated metals such as native copper and then bronze before the emergence of iron. In Africa, the Late Stone Age was directly succeeded by an Iron Age in which iron working gradually assumed a position of dominance over other metals such as copper (Woodhouse 1998). Bronze was often only worked centuries after the working of iron was already adopted and developed (Chikwendu *et al.* 1989, Miller and van der Merwe 1994a). Africa's deviation from the generally accepted sequence of technological progressions from the Stone Age through the Bronze Age to the Iron

Age has evoked serious debates and doubts regarding the origin and antiquity of its iron metallurgy (Holl 2000, Killick 2004b, Miller and van der Merwe 1994a, Schmidt 2001, Woodhouse 1998). Two antagonistic schools of thought have emerged, with the first and earlier one contending that Africa obtained its knowledge of metallurgy through the diffusion of ideas from the Middle East (Cline 1937, Gowland 1912, Oliver and Fagan 1975, Pearce 1960, Tylecote 1976). The second view posited that African metallurgy was indigenous in authorship with local smelters and smiths experimenting with the technology over a long period of time (Andah 1979, Diop 1968, Schmidt 1997, Woodhouse 1998).

The single origin hypothesis

Proponents of this view posit that knowledge of exploiting metals originated in the Middle East and then spread to sub-Saharan Africa with Meroe in the Sudan and the Carthaginian colonies in North Africa being touted as the possible conduits. On technical grounds, it has been argued that for iron working to develop independently there must be evidence of working less complicated metals such as copper, as is the case in the Near East, long regarded as the cradle of metalworking (McIntosh and McIntosh 1988, Tylcote 1976) where native copper was first worked around 6000 BC with the smelting of carbonate and sulphide ores being adopted gradually in the succeeding millennia (Brown 1973, Tylecote 1976). Subsequently, copper was alloyed with first arsenic and then tin to make bronze. Initially, the exploitation of iron commenced with the exploitation of meteoric iron in the Late Bronze Age in places such as Anatolia. However, around 1200 BC iron was smelted at sites such as Tel Chagar-Bazar in northern Syria (Craddock 1995, Pleiner 2000). Iron production was partly seen as an ultimate consequence of using iron rich stones as a flux in reducing copper from a wide range of its ores (Pleiner 2000, Tylecote 1976).

From this source area, the knowledge of iron working is thought to have spread to other areas such as Europe and Egypt where it replaced the dominance of bronze as the main utilitarian metal. Eventually knowledge of iron smelting reached sub-Saharan Africa. However, in Africa south of the Sahara, there seems to be no evidence for a preceding Copper or Bronze Age as in Eurasia, leading many researchers to believe that the technology was exotic in origin. It was argued that as a high temperature process the working of iron needed an earlier pyrotechnology such as copper working to develop (Cline 1937, Gowland 1912, Rickard 1939), thus making the case for the external authorship of African metallurgy (Killick 2004c, McIntosh and McIntosh 1988, Phillipson 1985, Tylecote 1975). The smelting of iron involving the melting away of the impurities in the ore leaving a spongy like agglomeration of solid metal was perceived to be a very complex process when compared to copper smelting. According to Phillipson (1985, p.149), "because the associated technology is so complex, and in earlier African societies no other process involved heating materials to such high temperatures, we have to consider the possibility of a northerly source of sub-Saharan iron working knowledge rather than duplicate independent discovery".

With this external source in mind, archaeological research was devoted to looking for the centres of dispersion and the routes which the diffusion process took. In the early 20th century, large quantities of ferro-working remains were discovered at Meroe in the Sudan. For some, the furnaces at Meroe clearly resembled those from Egypt which demonstrated a Roman influence and thus a Mediterranean origin (Shinnie 1966, Tylecote 1975). In the absence of detailed and systematic research in other parts of Africa, it was believed that knowledge of iron working therefore spread during the Roman period from Egypt *via* Sudan to West Africa and the Great Lakes region and subsequently to southern Africa. However, Tylecote (1968, 1975) investigated the iron working remains at Taruga, an Early Iron Age site in Nigeria, and compared them with those from Meroe. He noted that the ferro-metallurgical remains from the two localities had many points of divergence suggesting that they did not derive from a common ancestry. For instance, whilst the furnaces from Meroe were constructed using mud brick, those at Taruga were built using pile mud. Technologically, Meroitic furnaces were slag tapping in contrast to the Nigerian ones which were non-slag tapping. Moreover, the Meroitic furnaces are demonstrably later i.e. Roman in date as Woodhouse (1998) has shown. This suggested the existence of separate metallurgical traditions in the two regions which led Tylecote (1975) to conclude that Meroe was not the source of sub-Saharan African metallurgy. Tylecote therefore postulated that knowledge of iron working in West Africa must have originated from the Mediterranean *via* the Carthaginian colonies in North Africa.

The supposed link between the Carthaginian settlements and sub-Saharan metal working has been severely undermined by the lack of archaeological sites or finds demonstrating such a technological transfer (Holl 2000). The dating evidence currently available also seems to rule out any Carthaginian source of iron working in the inter-tropical region. The Carthaginian evidence for metallurgy appears almost at the same time as that in most parts of sub-Saharan Africa dating to the last millennium BC (Holl 2000, p. 14). Killick (2004c) has reported evidence for early copper working in the region of Mauritania which might act as a useful link between Carthage and West Africa, though it does not change the available dates. Until new and substantive evidence is generated, the link between the Carthaginian settlements and sub-Saharan African metal working, though promising, will remain at best speculative. Furthermore, the discovery of copper working thought to predate the use of iron in the Agadez region of Niger appeared to weaken this single origin model which had ruled out independent invention on the basis of a deficiency in an earlier pyrotechnology (Holl 2000, p. 15). Grebenart (1987) classified the metal working at Agadez sites into two phases, Copper I and Copper II. The Copper I period dating to around 2000BC was characterised by the exploitation of copper carbonate and oxide ores. This first period was followed by Copper II phase dating to about 1000BC in which iron and copper were simultaneously exploited. However, a subsequent and more detailed archaeometallurgical analysis of the metal processing residues from Agadez found no definitive evidence for copper working preceding iron metallurgy in Niger (Killick *et al.* 1988, McIntosh and McIntosh 1988). These later studies revealed that Grebenart's conclusions were based on defective evidence, faulty dates and above all faulty observations. Killick *et al.*'s (1988) studies demonstrated that the dating of the Copper Age was faulty since the charcoal used was from old wood, which meant that the dates obtained were significantly older than the actual metal working episodes. More importantly, of the furnaces assigned to copper working in Copper I, only one proved to be associated with metalworking and in that case it turned out to be an iron-working furnace. A re-evaluation of the Agadez evidence thus revealed that there was no Copper I or Copper II, and with that expectations of an independent invention of metallurgy in Africa dwindled into insignificance (Killick 2004c, McIntosh and McIntosh 1988, Phillipson 1985).

Multiple origins hypothesis

In its early form, the monophyletic or single origin hypothesis was influenced by European ethnocentricism which denied Africa the capacity to innovate. It is therefore not surprising that the diffusionist view on the origins of African metallurgy came under scrutiny from African scholars leading to the emergence of alternative views that argued for multiple centres of origin for metalworking on the continent. In its formative stages this position of multiple centres of origins for iron working was as speculative as the diffusionist theory that it sought to replace because it was not supported by any tangible evidence. Diop (1968) and Andah (1979) argued that iron working may have been discovered in Africa by accident during the firing of pottery. They argued that the process of firing pottery generated heat which in some cases approximated around 1000 °C, temperatures which are approaching the liquefication of slag in the bloomery production of iron. With the abundance of pottery making communities in the sub-continent, it meant that some areas could potentially have developed their own metallurgies. Critics of this view argue that there is no apparent relationship between the two pyrotechnologies as iron smelting involved reduction in combustion vessels while pottery was fired in the open (McIntosh and McIntosh 1988). This, however, ignores the fact that in some societies such as the Shona of southern Africa pottery was fired in pits dug in the ground (Bourdillon 1976, Posselt 1924). Archaeologically, there are cases of iron smelting furnaces which consisted of pits dug in the ground demonstrating that iron can be reduced in any environment provided the right conditions are met (Celis 1989, Pleiner 2000). In addition, the firing of iron rich soils can cause slagging and experimentation. For example, at Toutswe in Botswana, there are hut foundations which contain puddle slag (Kiyaga-

Mulindwa 1993). The different furnace types such as slag pit furnaces and natural draught furnaces would be products of local innovation and experimentation.

Following the unearthing of new "empirical data" at several localities throughout sub-Saharan Africa during the second half of the 20th century, the theory of polyphyletic origins seemed to get some support (Andah 1979, Schmidt and Avery 1978, van Grunderbeek 1981, Woodhouse 1998). The discovery of iron working sites in Rwanda, Tanzania, Burundi, Nigeria and Gabon all predating and in some instances contemporary with the production of iron in the so-called conduit areas was testimony to this view. The earliest known evidence for iron working at Taruga in Nigeria was dated to about 800 BC, Do Dimmi in Niger – 930 BC, Otumbi in Gabon – 910 BC, Tanzania, Rwanda and Burundi – (now calibrated to) 950 BC, and Cameroon – 800 BC. This prompted archaeologists such as Andah (1979) to conclude that because of this parity in the dating evidence it becomes difficult to argue for a north to south spread of iron working. Hence, it is possible that from multiple centres of origin scattered across the continent knowledge of iron working then spread to other areas such as southern Africa.

There are some objections to these earliest dates for metallurgy in Africa. This is because the levels of carbon in the atmosphere were fluctuating between 800 and 300 BC making ^{14}C dates falling in that time bracket impossible to differentiate (Killick 2004c). Another issue of concern is the fact that the charcoal used to date some of these early sites may have been obtained from old wood and thus the dates obtained were not for the iron working activities. Killick (1987) has argued that the old wood problem is very serious so that all the dates must be cast aside and new methods such as archaeomagnetism or thermoluminescence must be utilised to obtain absolute dates for establishing the chronology at the early iron working sites. These sentiments are not widely accepted by archaeologists who argue that it is difficult to imagine sites scattered across the sub-continent being affected by the same problem (Holl 2000, Schmidt 2001). Furthermore, it is not clear by how long the old wood problem has affected the dating of these earliest iron working practices. In addition, the old wood problem is negated by the fact that French archaeologists working in the Niger area have used thermoluminescence dating and obtained more or less the same dates as those argued to have been affected by the so-called old wood effect (Woodhouse 1998). The tenuous nature of the evidence linking the origins of sub-Saharan metallurgy with Carthage, the old wood problem and the contradictions inherent in the single origins view suggest that for the time being iron in Africa must be seen as a product of local experimentation (Mapunda 2003).

Although the issue of the origins is still unanswered, it may be safe to argue that once established, the technology developed and changed across time and space (Woodhouse 1998). This is plausible in view of the fact that a comparison of iron production in Africa at any given place and period reveals more differences than similarities, thus demonstrating that once established, the technology developed in different ways in response to opportunities and constraints imposed by cultural and environmental considerations.

Ethnoarchaeology – social dimensions

With the accelerated rate of modernisation in Africa after the Second World War, and the availability of superior materials and technologies, there was a general belief by ethnographers and archaeologists working on the continent that indigenous iron working practices would inevitably become extinct without any trace if it was not salvaged for posterity. The few surviving smelters and those who had observed or participated in the process were elderly and the craft was dwindling due to competition from industrially produced scrap iron in some areas (Goodall 1944, 1946). Also, the practice of iron smelting was generally discouraged by colonial administrators and missionaries from very early times because they perceived the procreational beliefs inherent in indigenous production to imply that African iron smelting perpetuated witchcraft (Reid and MacLean 1995).

From the 1960s up to the present, archaeologists and ethnographers recorded many features of traditional iron working with a view to recording all the stages in the production process. Van der Merwe and Scully (1971) conducted an ethnographic study among the BaPhalaborwa, a Sotho speaking group of people in South Africa. Through oral historical research and personal observations, they detailed many aspects of their iron working from raw material selection through its transformation into metal to the spatial organisation of iron working activities. They obtained information regarding the types of fuel used (charcoal from *Combretum imberde*), the extraction of the ore and the rituals practised associated with iron smelting. Their research also showed some relationships between the ethnographic and the archaeological record regarding the working of iron by successive Sotho polities. The crafts of the BaPhalaborwa to which iron technology belong have since been destroyed by large scale mining operations and van der Merwe and Scully's work is one of the few records surviving on this important iron working group.

Rowlands (1971) documented the process of iron smelting as it was conducted by several groups in the grasslands of Cameroon. His study has recorded successive human actions and technological choices taken by smelters and smiths in the practice of their craft. Noting the accelerated rate of social change and the resultant decline in indigenous iron working among the Bahaya of Tanzania, Schmidt (1978) conducted some ethnographic studies to record the practice of iron working (before it vanished without any trace). Schmidt also augmented information obtained from oral histories with that observed during smelting reconstructions. He recorded important information on raw material acquisition, the actual smelting and the cultural factors involved in indigenous iron working.

Using her experience of working in Buhaya with Schmidt (e.g. Schmidt and Childs 1985), Childs (2000) has conducted an ethnographic study of iron working among the Toro of western Uganda. She embarked on several field seasons to collect data through interviews with people who had directly participated in the process. She gives a detailed and very useful account of bloomery production among the Toro through the recollections of Adyeri who participated in the process in the early twentieth century. Childs highlighted the principal players involved in iron working, issues of mine ownership, rituals and taboos as well as the celebrations that accompanied the production of iron, a metal that brought wealth to the Toro societies. Toro iron working was divided into specialist tasks with full time bellows and tuyere makers who sold their products to the smelters and smiths. The working of iron was organised along kin lines. Childs also gives an insight into the procreational beliefs of the Toro. She observed that the bellows of the Toro iron workers were gendered with male and female bellows being used to generate the blast that propelled the chemical reactions in the furnace. As Childs rightly pointed out, her principal informant died in 1995, and without her work revealing his knowledge, the rich information on Toro iron working would have been lost.

The ethnographic studies conducted in the last four decades are limited, however, in that most people who were interviewed or who participated in the salvage reconstructions had been inactive for so long that the data obtained may be at variance with the art of iron working as it was practised by actual smelters and smiths. While the majority of the ethnographic studies were culturally focussed, very few attempted to document the technical aspects of the smelting processes. For example, Schmidt (1997) reconstructed both the socio-cultural and technical parameters involved in the actual smelting such as the quality of the ore, the temperatures achieved in the furnaces and the efficiency of the process. Furthermore, he conducted several smelting experiments and analysed the remains from the production process using standard metallurgical procedures. He then compared the results with those obtained from similar artefact suites from the Iron Age. Although his results did not show significant variation in terms of efficiency for example, their importance lies in that they pointed to the potential of studying local histories of technology incorporating all aspects of the production cycle.

According to Haaland (2004), iron smelting among the Tsara people in Oska Dencha, in south western Ethiopia is a vanishing tradition. However, iron smelting is still being practised in the area and this gave Haaland a chance to document the process directly before it was threatened with the changes associated with modernisation. Haaland recorded the process of iron smelting from clay prospecting and the mining of the ore to the removal of the bloom from the furnaces. Chilacho, the head smelter, controlled the iron smelting operations and all the other assistants relied on his expertise. The ore was obtained from an area about one hour's walking distance from the village. Upon discovering the ore source, beer was poured on the ground by the head smelter as a sacrifice to his ancestors (Haaland 2004, p. 67). Tuyeres of different types (*zeida* or penis and *tsole* or foreskin of penis) were made by the head smelter and his wife who was a potter. The process of iron smelting was based on a low shaft forced draught furnace about 80 cm high with a slag pit half that depth. After about 10 hours of operation the smelting was terminated and the bloom was removed the following day. Instead of being broken down to remove the slag from the pit, the slag was removed through the shaft mouth leaving the furnace intact and ready for minor repairs before the next smelt was conducted. This case strongly shows that the use of slag pit furnaces was not always wasteful in terms of rebuilding the superstructure after every smelt (Haaland *et al.* 2005) Through building large furnaces which allowed a person to enter the furnace and remove the slag from the pit and make repairs, Chilacho was able to re-use his furnace for a long time and the tradition of constructing furnaces in that manner had a great time depth in the area.

The metaphors of human reproduction were central to iron production in Oska Dencha (Haaland 2004, p. 77). For instance, the two types of tuyeres used in smelting symbolised male sexual parts which clearly shows that iron smelting was equated with human copulation. Conceptually, the furnace (a woman) was impregnated with the penis (tuyeres) giving birth to the metal bloom. In the Tsara worldview, this symbolic link between iron smelting and giving birth is illuminated by the observation that women giving birth and furnaces, both polluting activities – are located in isolation (Haaland 2004, p. 77). However, the child was welcome home just as iron could be smithed within the living quarters. By comparing Tsara iron working with that documented by Todd (1985) among the Dime of Ethiopia, Haaland attempted to create regional traditions of iron smelting. For example, while the process was based on the same operating principles, it differed in certain respects with the Dime utilising large furnaces with 36 tuyeres while the Tsara employed comparatively smaller furnaces with less than thirty tuyeres. However, the technological or metallurgical implications of these differences have not been quantified. It would have been insightful to evaluate if such differences affected the quality of the end product. Also, while Todd focussed on the technological aspects of Dime iron working, Haaland's work among the Tsara dwells on the ideological connotations which makes it difficult to draw parallels regarding either the technology or the ideology between two groups of people. In a promising development, Haaland has submitted the iron working remains from the smelts conducted by Chilacho for detailed metallurgical investigation in the laboratory. There is no doubt that such work will complement the cultural data obtained from her study thus giving a balanced representation of the technology.

Another theme related to these ethnoarchaeological studies was the study of socio-cultural metaphors associated with iron production in sub-Saharan Africa. In some sub-Saharan African societies (e.g. Fipa of Tanzania, Toro of Uganda and Phoka of Malawi), explanations of the production of iron were deeply embedded within socio-cultural beliefs and thus were richly infused with cultural metaphors. As a result, it was felt that studies of African iron smelting could shed light on beliefs that are not limited to smelting such as gender relations, ritual and the obligations of the living to their ancestors (de Barros 2000). This is because social behaviour such as iron working is usually rooted in a conceptual framework that imposes order on the world and gives structure to human existence (Barndon 1996, Childs 1991a, b, Childs and Killick 1993, Herbert 1993, Ndoro 1991). The process of transforming iron ores into metallic iron was therefore seen as part of this world view that emphasised the link between the ancestors and the living. In some societies such as the Luba of central Africa, this link was well developed to the extent that there was a general connection between possession of knowledge of iron working, the power of ancestors and political leadership (de Maret 1985, 1999, Herbert 1993). In this case, the possession of the knowledge of how to smelt and smith iron created hierarchies in society which enabled some people to dominate others.

The origin myths of the historical Luba and Lunda kingdoms in the DRC talk of their founders as master blacksmiths who used their prowess in smithing to create chiefdoms with large followings (Childs and Dewey 1996, De Maret 1985, 1999). This is also attested by the use of non-utilitarian iron objects such as ceremonial axes and gongs as royal insignia in the two kingdoms. Similarly in Karagwe, a historical polity in the Great Lakes of east Africa there was a symbolic association between political leadership and iron working. This was shown by the fact that Karagwe leaders were supposedly blacksmiths (Reid and McLean 1995). In addition royal insignia such as cows were made of iron. By no means did all smelters hold privileged positions within society, however. As Haaland points out, smelters in Sudan and Ethiopia belonged to the lowest caste and thus occupied a very low status in society (Haaland 2004). This is because iron working was looked down upon in those societies because of its association with dangerous activities such as fire. As a low class, smelting groups lived in isolation from other people (Haaland 2004).

Ethnographic studies have demonstrated that indigenous iron production was often accompanied by rituals and symbolism. For example, van der Merwe and Avery (1987) highlighted that iron production among the Phoka of Malawi was influenced by magical issues such as the use of medicines to stave off witchcraft: failure to use these medicines could lead to an unsuccessful smelt. Such medicines were usually placed in pits or pots below the furnaces. Rowlands and Warnier (1993) have recorded the evidence of the use of medicine pits by smelters in the Grasslands of Cameroon. Ritual sacrifices were also often made during the process of smelting. For example, the smelters in the highlands of Ethiopia sacrificed goats to their ancestors so that they would help them to stave off malevolent spirits which could lead to smelts being unsuccessful (Haaland 2004). Such sacrifices also accompanied iron smelting in many parts of Africa from the Bassari of Togo to the Phoka of Malawi and BaPhalaborwa of South Africa.

As noted above for the Tsara of Ethiopia, the production of iron in some sub-Saharan societies was metaphorically linked with human gestation in as far as the furnace was perceived as a womb that gave birth to iron. In some societies such as among the Fipa of Tanzania, the construction of the furnace was accompanied by rituals that were used to prepare a bride on her wedding day (Wembah-Rashid 1969). This theme of linking human reproduction with iron production is also highlighted by the perception of iron furnaces as wives by the Phoka of Malawi (Childs and Killick 1993) (and as discussed above for the Tsara of Ethiopia, Haaland 2004). Among the Phoka, smelters were supposed to abstain from sexual intercourse during smelting. It was believed that "adultery" with their real wives would kill the unborn child (iron) and thus lead to an unsuccessful smelt. As a result, Phoka iron smelting furnaces were located in secluded places away from the village where smelters could not be tempted by their wives. In addition, smelting was believed to be a very dangerous activity involving the use of fire which necessitated its siting in places at a distance from residential areas.

In contrast, because smithing was seen as a less dangerous activity in some societies, it was not subjected to the rituals that pervade iron smelting (Friede and Steel 1986). As such, it was conducted within the centre of villages while smelting was done outside. Clearly, these are generalised observations for the spatial location of both smelting and smithing varied from society to society and from area to area.

Most importantly, rather than perceiving the technology of iron working in a fetishised form that lay wholly outside the social dimensions of smelters and smiths, considering cultural factors enables an understanding of how technology was rooted in other spheres of culture. However, the ethnographic approach can be criticised for re-enforcing the alleged role of ritual and magic by the apparent over-interest of some researchers in these aspects, which may have influenced the way some informants presented their knowledge. There is a known and distorting feedback loop that occurs in the process of gathering ethnographic data (David and Kramer 2001, Lane 2005, Renfrew and Bahn 1991). Moreover, by portraying iron smelting as a highly ritualised process, the technological histories that also constituted an important share of innovation and invention have been subordinated to a focus on ritual practice and beliefs surrounding iron production, thus producing an equally biased view of African pre-colonial iron smelting.

Technology

Over the course of the twentieth century, several professionals with a background in modern metallurgy became interested in understanding African iron working with a view to documenting the technological aspects of the process. These metallurgists did some scientific and metallurgical studies of iron extraction debris in order to delineate the primary metallurgical reactions and the determination of a broad range of possibilities in the smelting technology of pre-colonial African societies (Stanley 1929, Todd 1985, Todd and Charles 1978, Tylecote 1975). In the absence of analytical laboratories in most parts of Africa, the relics of iron pyrotechnology like slag, furnace remains, ores and finished objects were taken and scientifically investigated in many laboratories outside Africa. In southern Africa, most early technical studies on remains from the production process and finished products were carried out by a South African professor of metallurgy called S. Stanley. Stanley's (1929, 1931a, 1931b) metallographic work on metal objects from sites distributed in the region represents the earliest attempt to gain an insight into metal fabrication methods in the Iron Age. Stanley analysed iron implements from Great Zimbabwe and established that they were made from wrought iron which was produced using traditional methods due to the varying carbon concentrations in the artefacts, and that those finished objects had inherited the slag from the initial reduction process. Furthermore, Stanley noted the absence of deliberate heat treatment such as hardening and tempering on the finished objects. There is no doubt that Stanley's pioneering work gave an insight into indigenous metal fabrication techniques, although the resultant technical information was not counter-balanced with socio-cultural roles of metal objects in the societies which manufactured them. In the case of Great Zimbabwe in particular, it would have been informative to examine artefacts and establish the similarities between functional and symbolic items.

In West Africa, Tylecote (1968, 1975), analysed slag, furnace remains and other iron extraction debris from Taruga, Nigeria. His metallurgical studies demonstrated that the bloomery process employed was not particularly efficient with respect to iron extraction because a lot of iron oxide was left in the metal. In addition, he generated a wealth of information on the types of ores, the charcoal used and methods of metal fabrication that were employed. Building on Stanley's (1929) pioneering metallographic studies on iron implements from southern Africa, Friede and Steel (1977) carried out some technical studies of iron slag and furnace remains from South Africa. Their study showed that most smelting groups generally preferred ores which existed in their vicinity, and contrasting remarkably with other communities that travelled tens of kilometres in search of good ore.

Killick and Gordon (1988) studied bloomery iron production in Malawi from a technical point of view. In the process, they demonstrated that indigenous smelters were able to produce good quality iron from a variety of ores, some of which are considered too low in their iron composition to warrant modern processing. In the last decade or so, Miller in a series of papers (Miller and van der Merwe 1994b, Miller *et al.* 1995, Miller 2001b, 2002) has conducted detailed metallurgical analyses of iron extraction debris as well as finished products from archaeological sites in South Africa and Botswana. Miller's studies were a necessary prerequisite to understanding the use of metals in society. His work has generated valuable information on iron production and fabrication. In an interesting development, Miller (2001a, b, 2002) has linked prehistoric metals production with the societal transformations that led to the establishment of socio-political complexity in southern Africa. For instance, trade in metals such as iron and gold introduced new forms of wealth like glass beads which enabled a few individuals to establish chieftainships. His work addresses the broader social and economic contexts that often accompanied iron production in southern Africa thus achieving a socially contextualised view of technology (Miller 2001b, 2002). Because of the ubiquity of iron working at many southern African archaeological sites, the strength of Miller's work lies in its recognition of the fact that the socio-political and economic life of Iron Age communities cannot be reconstructed fully without the integration of archaeometallurgical data into the interpretations of individual sites.

Archaeometallurgical studies of indigenous iron working conducted in Africa so far are limited by their failure to clearly identify and define primary smithing practices (Chirikure 2005). While there is a lot of evidence for iron smelting, the archaeological correlates of primary smithing are poorly known and the definition of the process has remained elusive. Perhaps this derives from the fact that the evidence for smelting is easily recognisable while that for smithing is not. However, Greenfield and Miller's (2004) study has shown the potential of defining primary smithing on the existence of bulk slag earlier on referred to as smithing hearth bottoms. Using the material from Ndondondwane, an Early Iron Age site in South Africa, they retrieved slags which they classified as smithing hearth bottoms on the basis of morphology. Subsequent laboratory analyses confirmed that the slags were indeed smithing hearth bottoms on the basis of sectioned sides and mineralogical composition pointing to the possibility of documenting prehistoric smithing on the basis of such residues and other archaeological evidence.

Within the broad paradigm of studying the technical aspects of African iron working was the claim that an advanced smelting technology involving the preheating of air entering the furnaces to produce iron with rich carbon content was practised in Africa since the Early Iron Age. Schmidt and Avery and Childs and Schmidt argued that most tuyeres discovered in several archaeological sites in north-western Tanzania had evidence of vitrification and reduced ends (Schmidt and Avery 1978, Avery and Schmidt 1979, Childs and Schmidt 1985). This was then used as testimony to the view that the tuyeres had been placed so that they penetrated deep inside the furnace to preheat the air inside the tuyeres before it reacted with the charge to achieve very high temperatures otherwise restricted to European blast furnaces. To support their case, Avery and Schmidt (1979) conducted an ethnographic re-enactment of iron smelting among the Buhaya people of Tanzania and obtained iron of varying carbon concentrations. Following their work, Kiriama (1987) has argued for the existence of the concept of preheating in Kenya. Interestingly, the placing of tuyeres deep into furnaces has been found to be commonplace and thus is not a unique eastern African phenomenon (Miller and van der Merwe 1994a & b, Prendergast 1979a). The significance of the preheating hypothesis has been challenged by metallurgists such as Rehder (1986). According to Rehder, the preheating of air that has been argued for did not raise the temperature in the furnaces to any meaningful levels. Also high temperatures could be achieved in furnaces without any preheating of the air before it left the tuyere. Despite the fact that the preheating hypothesis is not widely accepted by archaeometallurgists and archaeologists alike, Schmidt (2001) argues that the importance of this strand of research is that it attempts to explore innovation in African iron smelting which has eluded most researchers to date.

Developing new approaches

A closer look at the available data on iron working in sub-Saharan Africa shows that the process has been presented either as a set of beliefs, for example by Collett (1993) and Herbert (1993) without consideration of the interwoven technological aspects, or as a strictly technological practice devoid of any associated cultural features (see Tylecote 1975). New theoretical developments in archaeology and anthropology such as *chaîne opératoire* or technological style have shown that technologies such as iron smelting are concurrently material and socio-cultural. In order to achieve a fuller understanding of the past technologies there is need to use an approach that combines the two aspects. Thus research on iron production in Africa must go beyond an obsession with the ritual, symbolism and gender and power dynamics that has been the major theme in studies of iron working in the last few decades (Miller 1997, Miller and Killick 2004). The *chaîne opératoire* theoretical and methodological approach adopted in this study will therefore be utilised to marry the symbolic and technological worlds and thus obliterate the arbitrary divisions imposed in the perception of early iron production in the past. Above all, such an approach facilitates the reconstruction of the whole process of iron working from ore preparation, through the extractive process, manufacturing, use and the rituals and taboos involved in the process.

Using the archaeological and historical evidence, Schmidt (1997) has taken this line of investigation and showed that a fuller understanding of iron technology can be achieved by combining the scientific data with historical information in order to have an anthropological view of technology. His study in north-western Tanzania ultimately demonstrates that a historical perspective on iron working can be developed which gives prominence to choices and constraints and decision making processes involved in iron working (Schmidt 1997). The use of the direct historical approach enabled him to develop and establish a deep time view of Bahaya iron working. The use of oral data helped Schmidt to identify historical cases of iron working and archaeological sites such as Rugomora Mahe. By considering the Bahaya iron working diachronically Schmidt was able to determine issues such as continuity, innovation and variation amongst iron working practices of the Iron Age and recent practices. Schmidt's work can be criticised for relying too much on oral traditions to interpret cases of iron working dating to a thousand years ago. It is a known fact that oral traditions are limited in that they are easily modified and forgotten (Reid and Lane 2004), and to use them to explain cultural phenomena of such great antiquity might be a bit tenuous. Despite this, the strength of such a historical perspective is that it facilitates the determination of issues such as changes in furnace types, methods of organisation and socio-cultural factors over time.

Conclusion

There is no doubt that a consideration of the requirements essential for iron working and the themes that have dominated studies on iron production in sub-Saharan Africa has shown that studying pre-colonial iron production has a lot of potential which must be fulfilled by more research. Although the basic raw materials were identical across the subcontinent, the differences in the composition of ores, and clays for example stimulated local innovations. For example, because of the lack of high grade ores in their vicinity, smelters at Kasungu developed a technology of initially semi-processing the ores in natural draught furnaces and finished the process in bellows driven furnaces. Equally, the addition of sand to reduce the high grade magnetite ores in northern South Africa is another development that was stimulated by the local situation. Some societies such as those of Iron Age Nsukka, Nigeria, developed ways of improving output through slag tapping and the use of larger furnaces while some societies still used bowl furnaces. However, these technological requirements were accompanied by socio-cultural factors such as rituals and taboos which were also important to the success of every smelter and smith. This underscores the fact that technological studies must give equal weight to both cultural and technical factors related to the technology. The benefits of a joint framework are methodological and theoretical as it provides a coherent analytic process for studying the whole process of iron production from a material as well as a cultural perspective.

One of the major themes that have dominated pre-colonial iron production in Africa is that of its contentious origins. Whilst this perspective has yielded important information regarding the possible ways by which the metal might have been introduced on the continent, we know very little about the role of that technology in society. Thus more and more research must be devoted to understanding how the technology developed once it was introduced. This will shed light on issues such as local innovations, technological borrowing and even continuity in iron working methods over time. An over-concentration with the issue of origins also engages concerns that were central to the discredited theories regarding the adoption of technology in the sub-continent. This shows that perhaps considering how technologies developed may offer some leads as to how the technology may have been introduced.

Also, it has emerged from the review that most studies on iron working carried out to date reflect the disciplinary divide of the researchers. For example, those with a background in metallurgy were preoccupied with technological parameters (see Stanley 1929, Tylecote 1968). This is equally true of researchers from archaeology and its related disciplines who were concerned with cultural dimensions of pre-colonial iron working (see Herbert 1993, Ndoro 1991). So far, very few studies have utilised methodologies that bridge the gap between purely technological and purely sociological studies. The development of methodological and theoretical concepts such as *chaîne opératoire* no doubt helps to merge the two research strands that have dominated studies on African iron working. Old and limited approaches that thrived on disciplinary divides must be rejected in favour of those that concurrently consider the craft as simultaneously technological and socio-cultural.

Some of the modern ethnographic accounts of iron working have inherited the weaknesses of early studies such as those of Cline who tacitly assumed late 19th and early 20th century cases of iron working were primeval. By doing so, such approaches promote the picture of a static technology which as we have cursorily seen is not valid. This is well supported by the use of oral traditions gathered in the 1960s to interpret iron working sites discovered in countries such as Tanzania dating to AD 200. Obviously, it is very difficult to imagine that oral traditions can have a life span of close to a thousand years. In addition, some of the ethnographies were conducted decades after the communities had actively stopped smelting with the corollary that some reconstructions may have been authored to suit the whims of the researchers. Due to the inadequacies of such telescoped models, they must be discarded in favour of studies that strive to understand the full context of the development of technologies over time. Only this may encourage researchers to identify continuity and changes over time. Having exposed some of the inadequacies of previous approaches to iron production in pre-colonial Africa, the next step therefore is to examine if it is possible to consider the development of working in a single region - Zimbabwe. This makes it essential to present an overview of research perspectives that have dominated studies on iron working in the country to date. The next chapter therefore presents a review of studies on pre-colonial Zimbabwean iron production, focusing on the major research trends and ideas that have helped to form them. Ultimately, this will help to develop the context for diachronic and regional studies of iron working in the country.

Chapter Three: Zimbabwe's metallurgical past

Introduction

Research into the exploitation of metals in Zimbabwe has attracted several individuals from peripatetic scholars (Bent 1892, Hall 1910) to professional archaeologists (Huffman 1974, Summers 1969, Swan 1994, 2002) and metallurgists (Prendergast 1975, Stanley 1931b). This chapter discusses the metallurgical history of Zimbabwe with special reference to iron working. A consideration of the different works carried out over time shows that archaeologists tended to report chance discoveries of slag and furnaces. In the absence of analytical equipment, the studies were limited to the description of the furnace structure and the possible socio-cultural representations associated with iron working. Also, the currently available studies on iron working in Zimbabwe reflect the general picture of archaeological work carried out in the country which is geographically uneven. Also, because most studies were done by researchers with different research orientations, such works are isolated demonstrating the necessity to link them up in order to produce a broad picture of the development of iron production over time. Because of its late date, for the purposes of this study we can be reasonably certain on the basis of current evidence that iron production did not originate in Zimbabwe and is necessarily therefore an introduced technology (Mitchell 2001, Phillipson 1985, Pwiti 1996, Soper 1982).

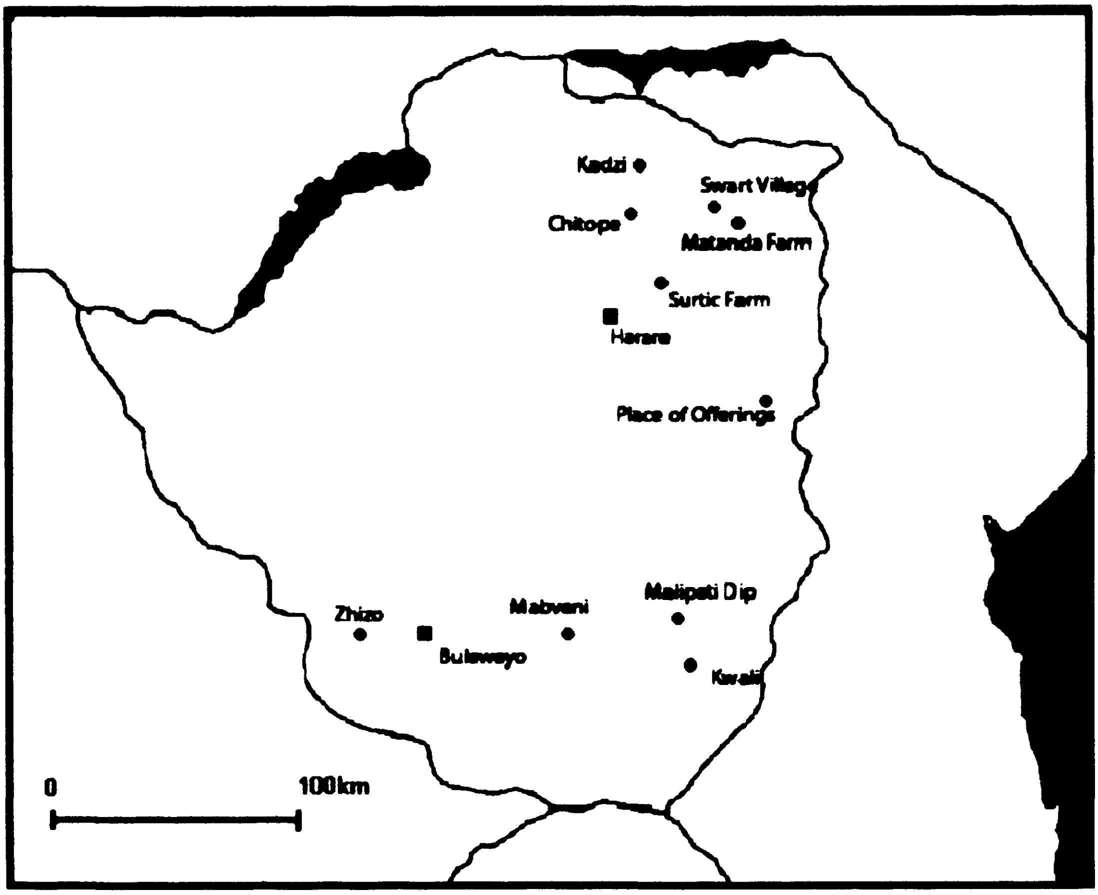
It is generally accepted that the earliest farming communities who are believed to have been Bantu speakers brought metal working technology to southern Africa (Mitchell 2001, Phillipson 1985, Soper 1982). As shown in the previous chapter, the origins of sub-Saharan metallurgy are still shrouded in mystery. Nevertheless, by AD 500, farming communities utilising metal resources in their vicinity were producing a repertoire of items such as iron and copper jewellery and small iron chisels and nails in Zimbabwe (Miller 1995, Robinson 1966, van der Merwe 1980). Metal working was crucial to the early agriculturalists in southern Africa who cultivated different varieties of millets and sorghum and kept cattle and small stock (Mitchell 2001, Phillipson 1985, Pikirayi 2001) and also appear to have relied more or less on wild animals (Pwiti 1996).

The history of metalworking in Zimbabwe took place within two successive chronological periods: the early to late first millennium AD (Early Iron Age) and the beginning of the second millennium AD to 1900 (Late Iron Age) (Prendergast 1974, Swan 2002). However, these chronological periods are now recognised to overlap as there are some Early Iron Age communities/sites that date to the early second millennium AD (Calabrese 2000). It is believed that from the introduction of metallurgy up to the third quarter of the first millennium AD, indigenous smelters and smiths exploited iron and copper resources (Miller 1995, van der Merwe 1980). Iron was produced from a wide variety of ores. The apparent rarity of the metal seems to have restricted its use to small implements such as arrowheads and objects of personal adornment. It is also possible that the larger objects were re-used to make these smaller products at the end of their working life. The evidence for larger utilitarian objects such as hoes, spears and axes increases towards the end of the first millennium AD (Miller 1995, 2001b, van der Merwe 1980). However, the fact that the preservation of finished iron objects improves towards more recent periods could also explain the difference in the frequency of iron objects in the early and late first millennium AD. During the same period, copper was smelted from carbonate ores such as the ones extracted from Copper Queen mine (c. AD 800) situated in north-western Zimbabwe (Swan 2002). Metallic copper was expertly worked into beads, bangles and other items of non-utilitarian value.

From the start, there appears to be a distinction in the utilisation of iron and copper in the Early Iron Age. While iron was used exclusively for both jewellery and utilitarian items, copper was used for fabricating non-utilitarian objects (Miller and van der Merwe 1994b). For instance, whilst iron adzes, arrowheads and other tools of everyday use dominate the upper strata at Kadzi (c. AD 700-900), the use of copper seems to be restricted to the making of bangles of different varieties and beads (Pwiti 1996, p. 134). The visual appeal of copper's red colour and its softer consistency may have promoted its continual use in objects of aesthetic value (Herbert 1984).

The existence of large quantities of iron slag, ore remains and broken tuyeres in association with hut remains and other material debris such as pottery, bone from domestic animals and beads (glass and shell) recorded at Early Iron Age sites such as Swart Village, Matanda Farm, Place of Offerings, Makuru and Surtic Farm indicates the development of more permanent settlements, where the production of iron over a long period of time at some of these sites would have left concentrated remains. Equally, the large quantities of copper slag recovered from an Early Iron Age site (c. AD 800) at the Chinhoyi Caves (Swan 2002) potentially suggests the development of permanent villages with possible specialist metalworkers. It has been suggested that craft technologies such as iron and ivory working were controlled along a political gradient in the EIA (Pwiti 1991, Calabrese 2000, Whitelaw 1994). Control of the knowledge of metal working may have aggregated with other factors such as ownership of cattle and control of ritual leading to the transformation from egalitarian to hierarchically organised societies (Pwiti 2005). This set the scene for the emergence of complex societies, precursors to the states of the second millennium AD.

Figure 3 **Map of Zimbabwe showing EIA sites mentioned in the text**



During the early part of the second millennium AD, new metals gold, tin and bronze were added to the range of metals exploited by indigenous metallurgists. Principally extracted from alluvial deposits and hard rock surfaces on the Zimbabwe plateau, the gold dust was subsequently smelted in small ceramic crucibles (Summers 1969, Swan 2002). Gold was mined for export via the Indian Ocean coast initially *via* Swahili middlemen and later through the Portuguese (Huffman 1974, Phimister 1974). Limited amounts of the metal were used locally for making objects such as beads and elite regalia. Such objects were recovered from sites such as Leopard's Kopje Main Kraal (Robinson 1959), Ingombe Ilede (Phillipson 1985) Mapungubwe (Calabrese 2000, Miller 2002), Great Zimbabwe (Caton-Thompson 1931) and Khami (Robinson 1959). By the 17th century the exhaustion of sources exploitable by the available technology and constant interference by the Portuguese in the local politics of the Zambezian states, such as Mutapa led to internecine wars and the eventual decline in the gold trade (Abraham 1959, Beach 1980, Chanaiwa 1972, Pikirayi 1993, 2001). Because of gold's inextricable link with long distance trade and royal control, it has been argued that gold was never in widespread local use (Herbert 1984, Huffman 1974, Summers 1969, Swan 1994). However, the systematic looting in the late 19th and early 20th centuries of many gold objects from archaeological sites by treasure hunters has jeopardised our attempts to understand the production and use of this metal in broader society.

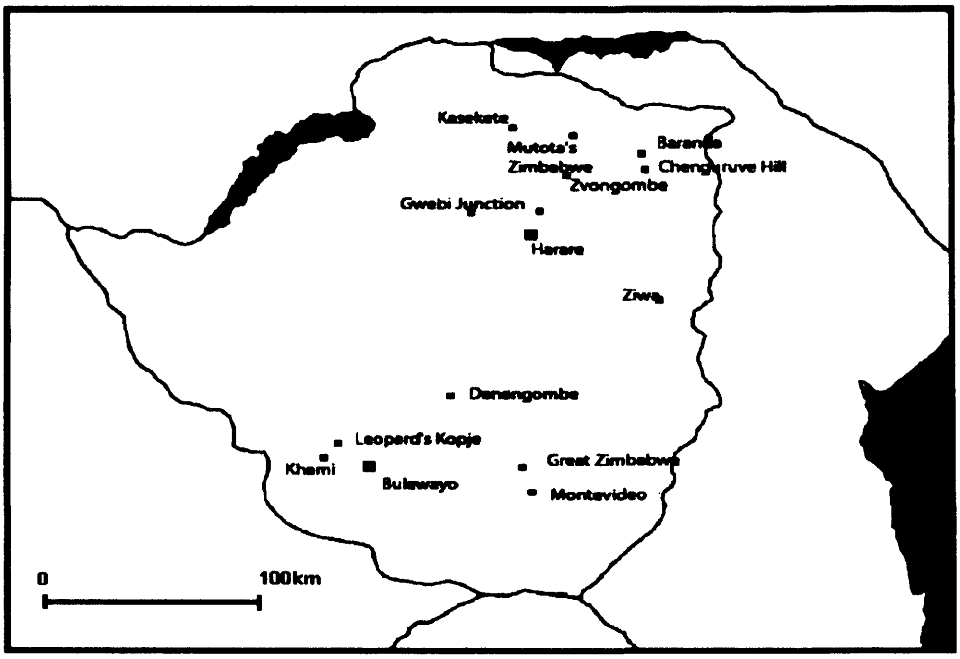
Another innovation in the metallurgical record of Zimbabwe during the early second millennium AD was the use of tin and tin bronzes (Miller 2002, 2003). Whilst the evidence for gold exploitation is fairly abundant, the evidence for tin is limited. Tin ore was extracted at Rooiberg in northern South Africa and smelted in considerable quantities in the vicinity of the mines and cast into ingots for transporting to trading cities such as Great Zimbabwe further north for export to the Indian Ocean seaboard (Grant *et al.* 1999, Miller 2003). A tin bar which is metallographically indistinguishable from those produced at Rooiberg was recovered in the valley excavations at Great Zimbabwe, corroborating that the site acted as a conduit for the Rooiberg tin to the outside world (Collett *et al.* 1992). Tin bronzes were fabricated into expressive items consisting mainly of royal insignia, bangles and beads. The fact that bronze was discovered only much after the advent of iron suggests that the metal was exploited more for its aesthetic appeal rather than for its physical properties (Miller 2003). Recent metallographic work on a large corpus of bronze artefacts from elite sites in Botswana, South Africa and Zimbabwe has shown that they had varying tin concentrations with some artefacts containing as high as 15% tin (Miller 2002).

The early second millennium AD also witnessed the flourishing of internal and external trade in copper and iron. In the south-western part of the plateau, indigenous metallurgists thought to be Mbara (a group of Western Bantu speakers) intensively worked copper from such areas as Copper Queen and Hurungwe at around AD 1000 (Swan 2002). The copper was smelted and either fabricated into various objects or cast into ingots which were exchanged for produce from other areas of the plateau. Copper ingots identical to the Katanga crosses (from central Africa) have been recovered from sites in the Hurungwe area as well as at Ingombe Illede in southern Zambia and beyond (Garlake 1970, 1971a, b, Herbert 1984). As the evidence shows, this trade was not limited to non-ferrous metals for iron was traded as well. Arabic chroniclers mention the existence of trade in iron between the east African coast and the inhabitants of the Zimbabwe plateau area since the beginning of the second millennium AD (Mackenzie 1975). However, these sources are limited and these are discussed below.

The existing metallurgical record of Zimbabwe and adjacent territories tends to focus on elite sites and gold and copper which were attractive to treasure hunters and archaeologists who followed in their wake (for example McIver (1906) and Caton-Thompson (1931); see also Swan (1994), Summers (1969, and Miller (2002).

Archaeology in the country emerged as an appendage of the colonial enterprise which sought among other things to amass large amounts of wealth. The British South Africa Company (BSAC) sponsored antiquarians such as Theodore Bent and Richard Hall who ransacked Zimbabwe tradition sites. It is believed that large quantities of gold objects and finely worked copper and bronze artefacts were looted from Great Zimbabwe and related sites by these treasure seekers and antiquarians without any contextual documentation (Miller 2002, Summers 1969). At the same time iron working assemblages were discarded at Danamombe and other *zimbabwes* ostensibly because they were products of the Bantu who occupied the sites in the wake of their abandonment by the original exotic builders of the dry-stone wall built monuments. Thus, the evidence for indigenous metallurgy has greatly suffered from the destructive activities of the colonial antiquarians and treasure seekers (Miller 2002). The focus on elite sites has meant that very little is known about metal production and use amongst the non-elite members of the society.

Figure 4 **Map of Zimbabwe showing Late Iron Age sites mentioned in the text.**



This antiquarian interest in precious metals has influenced the perception of professional archaeologists who became preoccupied with researching copper and gold but not iron. In his book on ancient mining on the Zimbabwe plateau, Summers (1969) gave extensive coverage to gold and copper while arguing that the abundance of iron at almost every Iron Age site meant that it was of no economic value. This thinking created a research bias towards gold and copper. For example, there are two books (Summers 1969 and Swan 1994) that comprehensively cover copper and gold working in the country while published works on iron tends to be unconnected reports of chance discoveries of furnaces and slag. This somewhat belittles the important role that iron production and use has played in the development of past societies.

Early encounters with metal working in Zimbabwe

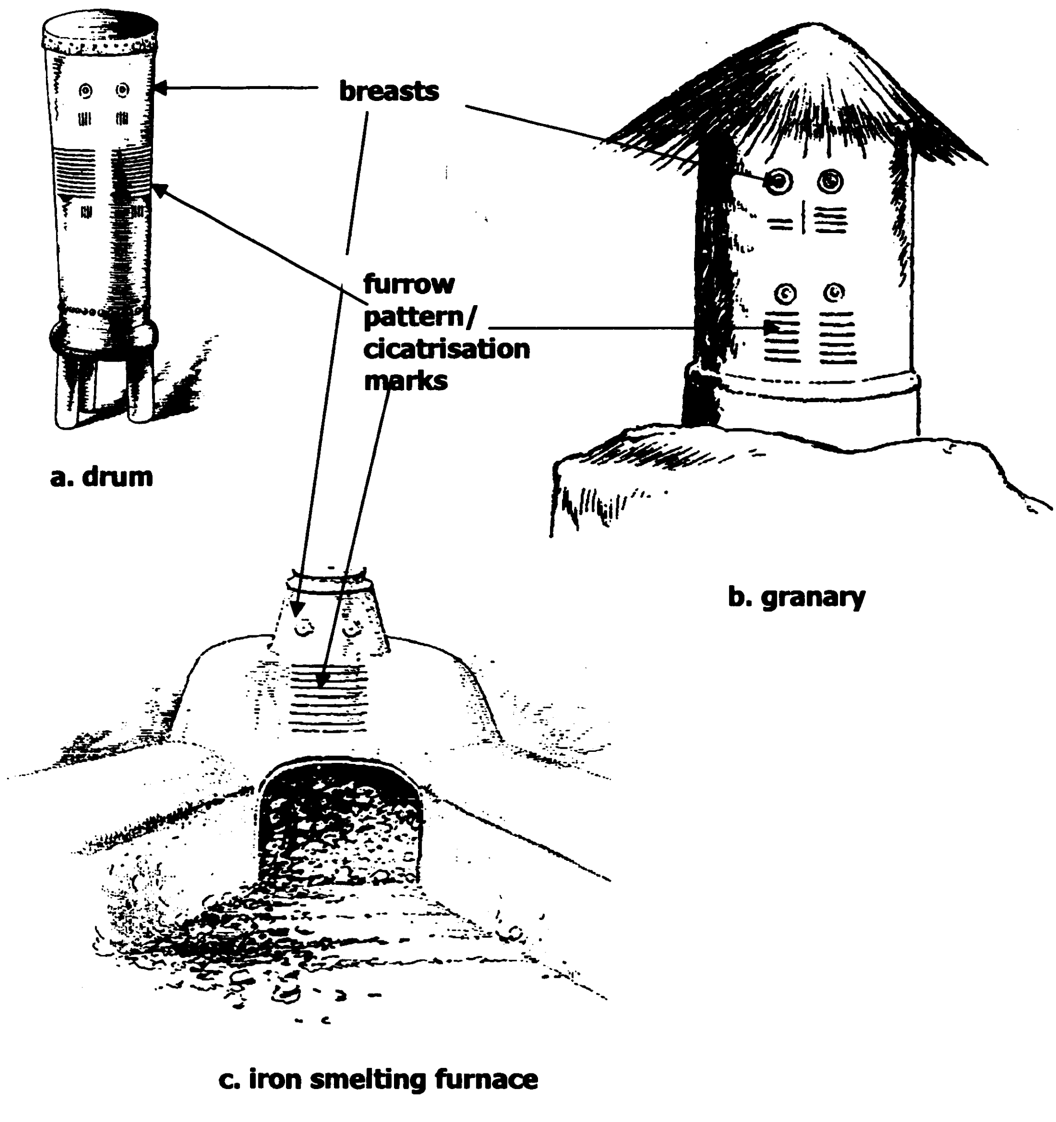
The earliest documentary reference to metal working on the Zimbabwe plateau dates to around AD 1200 when the Arabic writers al Idrisi and al Masudi made reference to the existence of a very competitive and blossoming iron trade between the Indian Ocean seaboard and the hinterland of Sofala (Mackenzie 1974a, Prendergast 1974). The early cartographic sources on the Indian Ocean coast seem to suggest that this area (the hinterland of Sofala) is synonymous with the Zimbabwe plateau area (Beach 1980, Mackenzie 1974b, Pikirayi 1993, Prendergast 1974). What is clear is that by the period in question, numerous archaeological sites on the Zimbabwe plateau such as Kadzi, Chitope and Surtic Farm had contact with the Indian Ocean coast as shown by the recovery of *conus* shells and translucent glass beads (Pwiti 1991, 2005). Similar developments have been noted in the Limpopo valley and in northern Botswana. It may be possible that iron production recorded at Kadzi and contemporary sites was part of this long distance trade. In the absence of strong evidence, whether iron production was part of this wider regional connection in this early period or not is still a matter of conjecture.

Although the Portuguese were obsessed with gold production, they occasionally mentioned the existence of iron production in the Mutapa state. The locally produced iron was made into hoes which were traded not only with the Portuguese but also amongst the African societies themselves (Mackenzie 1975). Portuguese documents allude to the fact that iron hoes became a medium of exchange and some form of currency in which value was measured (Mackenzie 1974a, 1975). It is therefore not surprising that the successive kings of the Mutapa kingdom levied tribute in the form of iron hoes. It has been suggested that locally manufactured iron was of superior quality which even surpassed that brought by Portuguese traders (Mackenzie 1974a). Several questions, however, emerge from a critical scrutiny of the sketchy Portuguese sources. For example what was the role of iron in broader society and who controlled the production of the metal? In addition, we do not know whether the iron working was accompanied by socio-symbolic factors or not. That the documents are silent on these crucial aspects demonstrates that there is need for detailed studies to augment the sketchy picture they depict. By the 18th century, the Portuguese were confined to the coast after their expulsion from the plateau by the Changamire armies in the 17th century (Beach 1980, Chanaiwa 1972, Mudenge 1988).

Ethnographic Observations

This section considers the ethnographic observations and studies carried out by quite a lot of individuals from the turn of the 19th century up to the present thus acting as a background to chapter four which deals with late 19th and early 20th century iron working among specific groups. In his travelogues, Bent (1892) observed iron working and other facets of local culture across most of what is now Zimbabwe. In Chivi, south-central Zimbabwe, and at Kunzvi's kraal near Harare he reported the existence of iron smelting furnaces which were built in the form of seated women and were breasted and decorated with scarifications resembling shallow furrow patterns. According to Bent (1892), iron smelting was metaphorically linked with human reproduction and it was thus practised in private far away from non-smelters and social groups such as women and children. Because of its link with reproduction, smelters were supposed to abstain from sexual intercourse with their real wives when smelting. The smelters also used medicines which were kept as a secret to protect the smelts from the inauspicious sorcerers. Interestingly, Bent also noted that the "breast and furrow" decoration and other designs meant to enhance the sexuality of women appeared on furnaces, domestic architecture (for example granaries) and pottery indicating that reproductive metaphors were expressed on many other aspects of the material culture of society (Bent 1892, p. 268) (**see Fig 5**). Because of his eurocentic ideas, Bent treated iron working with disdain arguing that ritual may have inhibited progress in indigenous iron working.

Figure 5 shows that most items of Shona material culture were decorated with human features including drums and granaries which were used in public domains (after Bent 1892)



In the meantime, the missionary Schimmin (1893) recorded what he saw or heard about local iron working practices. In his journey to Gambiza in central Zimbabwe, Schimmin encountered several iron smelters but he was awe struck by iron working among the Njanja which was organised on industrial lines in terms of output and scale, a very significant aberration from what existed among contemporary ethnic groups in Zimbabwe. Unlike his contemporaries who were motivated by ethnocentric ideas, Schimmin seems to have been impressed by Njanja iron production which he equated with that of contemporary Wolverhampton in England. This is despite the fact that leading Njanja smelters claimed to derive their success partly from their expertise and partly from their unique medicines. Obviously, this involvement of magic in Njanja iron working demonstrates that Schimmin had a different attitude to indigenous technology when compared to people such as Theodore Bent who viewed it with contempt.

The Native Commissioner of Charter District, now Chikomba in central Zimbabwe, F. W. Posselt took a keen interest in recording several aspects of Njanja iron working from ore preparation through smelting to smithing in the mid 1920s (Posselt 1926). Posselt tirelessly encouraged the Njanja to continue with their craft which was in decline among most African societies partly because of the availability of cheap scrap iron and partly because of missionaries whose onslaught on rituals discouraged people from smelting in some areas. The Njanja iron working deviated from its contemporaries in domains such as the absence of sacrifices and this could explain why Posselt actively encouraged them to smelt when everyone else was being discouraged. It appears that Posselt had a positive attitude towards African technologies and crafts even if the Njanja used medicines.

The Njanja performed their art of iron smelting at several exhibitions such as the one held at the Queen Victoria Memorial Museum in Harare in 1944 (Goodall 1946, Franklin 1945). Franklin (1945) (who was also a colonial administrator) and Goodall (1944) (who was an archaeologist) carefully recorded the Njanja smelting and smithing processes. Before building the furnace, the leading smelter dug a small hole in the ground and placed some medicines arguing that iron could not be produced if they were not used. The Njanja furnaces were of a low shaft type with a provision for removing slag through the rake channel. Like the furnaces observed by Bent in Chivi, Njanja furnaces did not have the provision for slag pits. Instead, they contained a shallow depression in the ground designed to act as a charcoal bed. Goatskin bellows were used to pump the air. After the smelt, Njanja smelters expertly forged a wide array of tools such as knives and thumb piano keys (**see Fig 11**) (Franklin 1945), thus giving a glimpse into indigenous iron smithing. The Njanja forge consisted of a shallow oxidising hearth which was driven by a single pair of bellows. The smiths who were also smelters used hammerstones and stone anvils initially to refine the bloom and subsequently to fabricate the objects. Furthermore, Goodall recorded that the master smelter controlled the smelting and smithing processes. It would have been more revealing if the metallurgical aspects of the process such as the selection of clays used to make furnaces and their refractory qualities, the grade and type of ore and even the quality of the iron was recorded. These data would have illuminated a multitude of factors forming part of indigenous iron working. On the other hand, the lack of technical information is understandable if we consider the fact that Posselt and Franklin were not academics but were colonial administrators who were fascinated with African iron working.

After the Second World War, some professionally trained archaeologists and metallurgists realised the importance of studying pre-colonial African technologies such as iron working. For example, Prendergast (1972) conducted an ethnographic survey with the intention of understanding and investigating what remained of the knowledge of iron smelting in the Shurugwi area of Zimbabwe. Through interviewing older men in society who had smelted and or witnessed the craft being practised, Prendergast's study gives an interesting insight into all aspects of indigenous iron working such as clay prospecting, the types of furnaces used and the ore types which were exploited. In Nhema in Shurugwi, the ore was mined at Zinhedzi Mountain or was obtained through trade with Njanja entrepreneurs. Apparently his informants were familiar with different kinds of furnaces; some had used open bowl furnaces while others had used shaft furnaces. This division was primarily based on differences in the scale of production with bowl furnaces catering for localised needs while shaft furnaces were used to increase production beyond the immediate needs of the smelters (Prendergast 1972). Based on the information from the interviews, Prendergast then organised an experimental smelt which failed to produce any iron. Metallographic analyses of the slag showed that there was some liquefaction of the slag and some haematite was transforming into magnetite. The fact that smelters lacked practice and had to conduct the smelt on a trial and error method led Prendergast to conclude that iron smelting in the area had died completely because all the experts were dead. This study for the first time simultaneously gave an insight into the technology and cultural representations of iron working of a single group of people.

On his part, Mackenzie (1974a, 1975) studied the economic aspects of Njanja iron production. He collected oral traditions amongst Njanja elders and leading master smelters such as Headman Ranga (Zinwamhanga). The metal bloom from the furnaces was smithed and forged into tools which were traded over wide distances. There are apparent differences in terms of scale between the Njanja case and that of Shurugwi. This is because production in Shurugwi was localised while that of the Njanja was beyond local needs. Thus, smelters among the Njanja adapted to increased demand for their iron by conducting more frequent smelts in many furnaces while the low demand in Shurugwi meant that smelters could only use single furnaces at the same time smelting infrequently. It is therefore highly plausible to argue that the scale and nature of production is dependant on the issue of demand and supply (Costin and Hagstrum 1995, Costin 2002). By responding to the challenges brought in by the demand for example, Njanja smelters made some modifications and improvements in their organisation in order to meet the supply as will be seen in the next chapter.

Dewey (1990, 1991) travelled to Njanja country and produced a documentary on their iron smelting and smithing practices. The film contains important data on furnace preparation, the details of actual smelting processes and the smithing of objects. The film also captures the traditional songs and dances that were performed to entertain smelters. These cultural factors do not leave material traces in the archaeological record yet they were an important aspect of iron working. However, most of the late 19th and early 20th century data regarding iron working is at best descriptive and in some cases speculative. Unlike most observations by antiquarians, these studies by academics accorded indigenous iron production the status it deserves in archaeological and historical studies.

Archaeological evidence

In Zimbabwe as elsewhere in Africa, archaeological studies in prehistoric iron production commenced with the beginning of archaeology in the late 19th and early 20th centuries. Inspired by the Portuguese speculative views about the existence of the biblical goldfields of Ophir on the Zimbabwe plateau, the Ancient Ruins Company was formed under Rhodes's tutelage to search and obtain gold left by antecedent races in archaeological sites of the Zimbabwe tradition (Garlake 1973, Hall 1987). This external authorship of the site was reinforced by the negative attitudes stemming from the social evolutionism and the low regard for Africans that it was associated with. It was believed that gold objects and production demonstrated an exotic authorship of civilisations such as Great Zimbabwe while local objects such as iron hoes and pottery represented the occupation of the sites by Africans after they were abandoned by the advanced races (Garlake 1973, 1982). For example, Hall (1910) argued that such material culture (iron objects and local pottery) "was of recent Kaffir origin and decadence". He echoed Bent's earlier sentiments that "these ruins have been overrun for centuries by Kaffir races with knowledge of iron smelting who would at once utilise fragments of iron which they found for their own purposes" (Bent 1892, p. 176). The activities of the Ancient Ruins Company lasted for close to a decade, during which sites were plundered without any attempt to study the material culture and the context of recovery of the finds (Herbert 1996, Miller 2002, 2003).

Since the emergence of intensive archaeological research on the Iron Age in Zimbabwe, professional archaeologists have unearthed several sites with evidence of iron smelting and smithing, recorded in the National Archaeological Sites Database (NASD) in the Museum of Human Sciences in Harare. The database includes a list and descriptions of archaeological sites with finds consistent with iron working dating to the Early and Late Iron Age. Numerous Early Iron Age sites scattered across the whole country have yielded a large corpus of slag, broken tuyeres and in some instances partially reduced ores. While slag is ubiquitous, finds of intact furnaces are rare in the Early Iron Age. For most EIA sites, iron production evidence was recovered in similar contexts with architectural remains such as pole impressed daub, cattle bone, figurines and glass beads. The archaeological site of Mabveni in Chivi, south-central Zimbabwe has produced iron slag and finished objects such as chisels in association with typical Early Iron Age Gokomere pottery, cattle bones and architectural remains (Huffman 1975, Robinson 1961b). Despite being one of the few sites to produce the earliest evidence for iron working in the country, currently no metallurgical studies have been conducted on the iron production remains to gain an insight into the technology of the process in the middle of the first millennium AD. Other EIA sites in the region such as Gokomere Tunnel site near the modern town of Masvingo, Makuru in Mberengwa, south-western Zimbabwe and Malipati Dip in south-eastern Zimbabwe have also produced evidence of iron slag and broken tuyeres (Robinson 1963). Such remains were associated with other domestic debris indicating that iron working may have been conducted in settlement areas. Also, a sizeable quantity of tuyeres with finger impressions, slag and ore was excavated during an ongoing British Institute in Eastern Africa research project in south-eastern Zimbabwe directed by Carolyn Thorp, furnace slag was identified and it is associated with non-slag tapping furnaces (Swan pers. com). No intact furnaces were recovered from the site but the average internal and external diameters of the tuyeres are comparable to those from sites such as Tafuna Hill in northern Zimbabwe (see below). Elsewhere in Zimbabwe, iron slag dating to the late first millennium AD was recovered at the Place of Offerings in Nyanga, north-eastern Zimbabwe (McIver 1906, Summers 1958). The Place of Offerings has also produced evidence of ritual such as figurines. The glass beads suggest that the inhabitants at the site participated in long distance trade.

In western Zimbabwe several, EIA sites with evidence of slag have also been recovered though they belong to the later part of the first millennium AD. Finds of slag and finished objects were recovered from Zhizo, a site in the Matopos and

Mumurgwi located in northwestern Zimbabwe (NASD). Besides the general reporting no descriptions of the processes represented by the slag in the production cycle were made.

In northern Zimbabwe, a number of EIA sites have produced iron working remains. Pwiti (1996, p. 132) retrieved tuyere fragments, some iron slag and an iron adze from a post AD 800 context at Kadzi in the mid-Zambezi valley. The Kadzi slag was dense with charcoal impressions reminiscent of slag which solidified in the furnace. The internal and external diameters of the tuyeres were 60 and 80 mm respectively. It has been argued that large tuyeres are consistent with natural draught furnaces (Mackenzie 1975) although such an assumption requires more evidence to corroborate it. Still in northern Zimbabwe, Pikirayi (1993) reported the existence of large concentrations of iron slag at Swart Village, (a site more or less contemporary with Kadzi) situated on the banks of Mupfuri River in Mt Darwin. Apart from the general reporting, no collections of the material from the site were made. However, the abundance of iron working and other categories of material culture such as pottery indicate the potential of the site in addressing questions about the technology and spatiality of iron working in the Early Iron Age. Garlake (1971a)'s study at a terminal Early Iron Age site at Tafuna Hill in northern Zimbabwe yielded iron working evidence such as slag and broken tuyeres. The internal diameter of the tuyeres averaged 50 mm; their average external diameter was 70 mm only slightly larger than those studied by Prendergast at Surtic Farm (see below).

Prendergast (1983) made a detailed study of the iron pyrometallurgical remains from possible slag tapping furnaces at a terminal Early Iron Age site (dating to c. AD 1000) situated at Surtic Farm adjacent to the Ndoba Hills in the Mazowe valley about thirty kilometres north of Harare. As a professional archaeometallurgist, Prendergast described in detail the processes represented by the material scattered on the site. The Surtic ferro-metallurgical debris consisted of large concentrations of broken tuyeres, slag heaps and collapsed furnaces. The furnaces from the site were constructed with panels of clay with large quartz clasts. The internally flared air nozzles had an average internal diameter of 40 mm and an external one of 60 mm. The slag from the site was black and dense exhibiting the characteristic lava-like flow texture akin to that of tapped slag. According to Prendergast, the shapes of some pieces of the tap slag and the occluded sand grains suggest that the slag had cooled in shallow trenches. The "quantity and size of the blocks of tap slag from the Surtic site shows that these furnaces had a large capacity and that temperatures sufficient to produce tap slag were attained in them" (Prendergast 1983, p. 32). Obviously, such remarks would have benefited from detailed laboratory studies of the slag to ascertain whether tapping actually existed as non-slag tapping furnaces are known to produce fluid slag as well. Irrespective of this, Prendergast's observations can be trusted because in addition to being an expert in mineralogy he possessed several years of experience in dealing with bloomery slags (Miller and Killick 2004). The type of ore exploited on the site was a haematitic banded iron stone possibly collected from an ore outcrop in the vicinity of the site. Basing on the collapsed furnace remains, Prendergast argued that the furnaces at Surtic Farm were very large approximating one metre at the base. Such furnaces contrasted with many small furnaces widely used in the Late Iron Age. He therefore postulated that EIA furnaces were larger that those used in the later period.

Comparatively, many more archaeological sites have produced evidence of iron production in the Late Iron Age. While finds of intact furnaces are rare in the early second millennium AD, they become more abundant from the 15th century onward. Van der Merwe (1978) excavated an early Late Iron Age (Gumanye Tradition) iron smelting furnace (^{14}C dated to AD 1200) at Nenga Hill near Buhwa in south-western Zimbabwe. Collapsed furnace remains recovered from Nenga indicate that the furnaces were probably very large, exceeding one metre in both diameter and height. The tuyeres from the furnaces had striated finger impressions on their exterior surfaces and the internal and external diameters were 50 mm and 80 mm respectively. Because most of the slag from the Nenga furnaces was only partially fluid, van der Merwe (1978, p. 104) proposed that the furnaces were non-slag tapping. He further argued that the lack of interior oxidation in the tuyeres was consistent not only with bellows driven furnaces but also with furnaces devoid of the provision for slag removal during the process of smelting. Probably, magnetite pebbles from the nearby ore outcrop on Nenga Hill were smelted in these furnaces. While this study is important in showing some elements of iron production in south-western Zimbabwe, detailed archaeometallurgical analyses of remains from the production process would have provided information in domains such as temperatures achieved in the furnaces and the efficiency of the process, adding more weight to van der Merwe's assertions beyond a series of macroscopic observations. The Buhwa furnaces contrast strongly with EIA sites Kadzi and Surtic Farm in northern Zimbabwe. For example, while furnaces from Surtic Farm were possibly slag tapping and induced draught driven, the Buhwa furnaces were non-slag-tapping and bellows driven. This is suggestive of distinct metallurgical traditions for the two areas.

The NASD has a lot of sites contemporary with Nenga which have produced ubiquitous evidence of iron working. Iron slag, and finished objects such as bangles, hoes and iron beads were recovered by Robinson (1959) at the Leopard's Kopje Main Kraal in south western Zimbabwe. However, as with most sites excavated by non-metallurgists the recording was just limited to the mentioning of the finds with no detailed descriptions of the iron working remains.

Prendergast (1975) excavated an unusual iron smelting furnace in the Darwendale area about 50 km northwest of Harare dated to the 13th or 14th century AD. The furnace had a very large base with multiple tuyere ports (one bundle had four tuyeres that were fused together), all characteristics of the natural draught furnaces. This led him to postulate that such furnaces were probably operated by natural draught, an interpretation which metallurgists such as Killick (2004b) agree with. The internal diameter of the fused tuyeres was 30 mm while the external one was 53 mm. The Darwendale furnaces had holes at the base which accommodated medicines. Prendergast claims that these Darwendale furnaces may have developed as a response to the local ore which was predominantly magnetite rich in asbestos. This issue of natural draught furnaces is of particular interest because it had been claimed that they were not used south of the Zambezi River (Cline 1937). Prendergast summarised his work in different parts of the country and argued for the existence of two types of furnaces in the Iron Age of Zimbabwe; the large natural draught furnaces and the small shaft furnaces which were bellows driven. If validated, this proposition has great potential in showing innovations that took place diachronically. However his sample of sites was small, relying on very few sites clustered in northern Zimbabwe.

Ndoro (1994) discovered a possible natural draught furnace at Chigaramboni Hill near Great Zimbabwe in south central Zimbabwe. This furnace throws intriguing light onto the issue of changing trends of iron production in Zimbabwe's Iron Age. With the exception of Prendergast's Darwendale furnace, no natural draught furnaces are known from Zimbabwe in the historical period. Ethnographically, their distribution is restricted to the area between West Africa and northern Zambia (Cline 1937). This demonstrates the need for more research to understand this issue of natural draft furnaces and their distribution. Dating to the 17th century, Ndoro's furnace was characterised by large base diameters, multiple fused tuyeres and the absence of tuyeres with flared ends. Some of the tuyeres were fused in bundles with one group having four tuyeres. The tuyeres from the furnaces were large with internal diameters of 80 mm and external diameters of 100 mm (Ndoro 1994, p.32).

During the Zimbabwe period (1300 AD to 1800), finds of iron slag, finished objects and collapsed furnaces become more abundant. Finds of slag, arrow heads, spears and chisels were found from Zimbabwe tradition sites scattered across the whole country such as Montevideo Ranch, Chivowa Hill, Great Zimbabwe, Chomuruvati and Matendere in southern Zimbabwe. In western Zimbabwe, Khami, Danamombe and Regina are some of the sites that have produced iron working evidence while Harleigh Farm and Mutare Altar site are Zimbabwe tradition sites with iron working in eastern Zimbabwe. In northern Zimbabwe, Chisvingo, Zvongombe, Mutota's Zimbabwe, Yellow Jacket and Baranda, all belonging to the Zimbabwe tradition, have yielded iron working evidence. Several archaeologists have also reported the existence of iron furnaces, slag and finished objects associated with the terraces and pit structures belonging to the Nyanga agricultural complex in eastern Zimbabwe (Chirikure 2002, Chirikure and Rehren 2004, McIver 1906, Soper 2002, Summers 1958).

In contrast to the forced draught furnaces of Prendergast and Ndoro, a new and small furnace type seems to appear in the archaeological record in increasing numbers after the 16th century (Mackenzie 1975, Prendergast 1979a). These bellows driven furnaces were very small and in some cases possessed an internal diameter of no more than 40 cm. Such diminutive furnaces usually possessed between two and six tuyere holes at the back and a frontal opening known as the rake hole. The smaller sizes of the furnaces corresponded with smaller size of tuyeres. Good examples of these low shaft bellows driven furnaces were excavated by Prendergast (1979b) near the Zimbabwe tradition site of Chisvingo in Masembura communal lands, in northern Zimbabwe. Compared to the large tuyere diameters of the terminal Early Iron Age, the internal and external diameters of the tuyeres averaged twenty and thirty millimetres respectively. The lower Chisvingo site dated to around 1700 had a slag pit which contrasted with the Upper Chisvingo furnace (c. 1900) which had no slag pit. A review of the recorded sites shows that not many slag pit furnaces have been documented in Zimbabwe. The majority of the furnaces only have shallow depressions at the base to act as the charcoal bed. Such furnaces produced very little slag and seem to be the dominant furnace type in the historical period. Examples of these include those excavated by Robinson (1961c) in Chivi and those reported by Bernhard (1962) in the Nyanga agricultural complex area (discussed below). The existence of these small bellows driven furnaces further shows the existence of variation in iron working in the Zimbabwean ferro-metallurgical past. However, while this potential for change is suggestive, it remains largely unproven. It would be interesting to determine if the changes reported in furnace types and methods of blowing over time were necessitated by the need for improved efficiency or they were an adjustment to cope with factors such as the available raw materials.

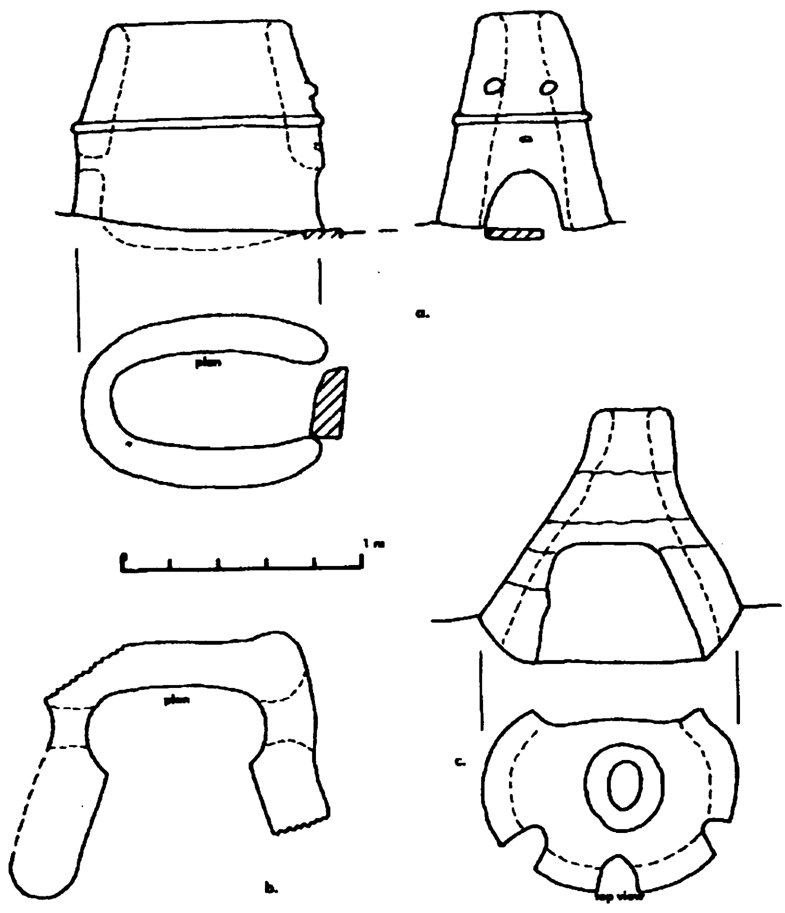
Mackenzie (1975) proposed that there were two types of bellows, the drum bellows which were used earlier and the bag bellows introduced from the eighteenth century. He argued that this development was introduced by new groups of people such as the Njanja who brought in new skills from their alleged homeland in the Zambezi valley. In the absence of tangible proof such as the recovery of bellows or documentary sources dating to the period in question, such an interpretation remains speculative.

Cooke (1959) gave a largely descriptive report on an iron smelting furnace in the Matopos in south-western Zimbabwe. According to Cooke (1959), the furnace was circular in plan with bosses which undoubtedly represented women's breasts. Because the furnace differed significantly from those utilised by other groups such as the Kalanga in the area, Cooke proposed that such type of furnaces were made by the Karanga who were probably making iron for the Ndebele in the 1896/97 Shona-Ndebele uprising and more research on the furnace types in the Matopos should shed more light on this. K. Robinson excavated two iron smelting furnaces located in a shallow gully in Chivi District in south-central Zimbabwe (Robinson 1961c). The furnaces which stood adjacent to each other were built of anthill clay. Furthermore, he remarked that they were decorated with breasts and other moulded features reminiscent of Bent's observations almost half a century earlier in the same area. He commented that in discussing the furnace types, one was limited by the lack of comparative material. However, he noted some major differences with Cooke's furnace in the Matopos. For example, while Cooke's furnace had flanking walls which presumably protected bellows operators from excessive heat, Robinson's furnaces did not have them. This may indicate separate metallurgical traditions for the areas though of course there is need for a larger sample for this statement to be more credible.

Bernhard (1962) gave detailed descriptions of iron smelting furnaces in the Nyanga area. He proposed a typological classification of furnaces and came up with two types; an earlier Type A of beehive shape was a later oval shaped Type B. On the basis of the state of preservation of the furnaces, Bernhard argued that the more intact oval shaped furnaces were more recent when compared to their beehive counterparts that were more dilapidated. Like many archaeologists in this period, Bernhard (1962) noticed some decorations of breasts and women giving birth in the later furnaces and argued that sexual symbolism pervaded Nyanga iron smelting. He further argued that Nyanga iron smelting furnaces were located in seclusion because of the rituals and taboos associated with the craft. Most of these Nyanga furnaces were located in low walled stone enclosures whose possible significance he did not bother to interpret.

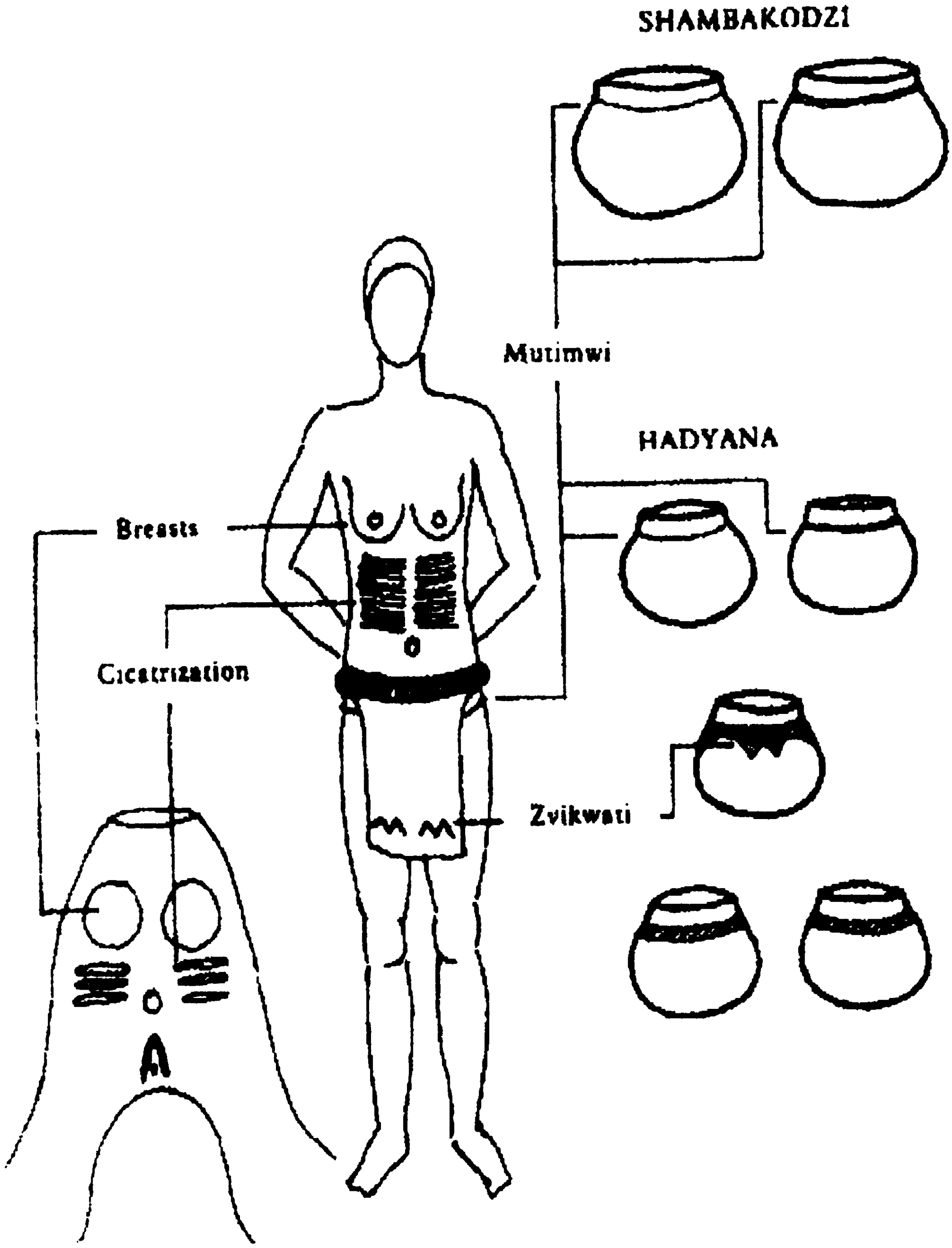
Soper's (2002) work sought to understand the agricultural basis of the Nyanga complex and pointed to the fact that the whole complex represents an agricultural community of industrious farmers and stock raisers. Iron played an important role in the socio-economic activities of the Nyanga Complex and the abundance of iron extraction debris was seen as a testimony to this assertion. Soper documented the ironworking sites in Nyanga and classified iron smelting furnaces into three types primarily on morphological considerations **(see Fig 6)**. The first type (type A) was oval with a mouth at end, belt, breasts and navel, while type B was oval with a mouth at side and projecting arms, and the third type (type C) was conical. These furnaces were clustered in different areas with type A being common in Nyanga National Park while type B was dominant in Nyahokwe and type C was generally found in Tsvitu. Because of their state of preservation, it has been proposed that these furnaces probably date from the late 18th century onward.

Figure 6 **Soper's Types of Furnaces from Nyanga (a) oval with mouth at end, belt, breasts and navel, Upper Pungwe (b) oval with mouth at side and projecting arms, Nyahokwe (c) conical, Tsvitu. Illustrations adapted from Soper (2002, p. 116)**



Collett (1993)'s research sought to understand the socio-cultural factors associated with pre-colonial iron working in south-central Zimbabwe. His work showed that fertility symbolism was inextricably linked with Karanga iron smelting as shown by the existence of gendered features on furnaces. Furthermore, Collett highlighted that the designs which were replete on Karanga iron smelting furnaces such as breasts, tattoos and scarification marks also featured on other categories of material culture such as items of clothing and clay pots **(see Fig. 7)**. This observation was also made by Bent (1892) in the same area **(see Fig 5)**. Collett thus posited that metaphors of creation and fertility pervaded the Karanga worldview. Despite this important observation, Collett posited that iron smelting was located away from villages because of its association with human copulation which was a private activity. If fertility symbolism was expressed at every level of society (in both public and private places) then the next question to ask is was it important in determining the location of iron smelting as has been frequently argued. It is possible that the fertility symbolism expressed on smelting furnaces reflected the society's cosmology and may not have been the only determinant in the location of iron in secluded areas. Obviously, there is need to conduct in depth studies of several cases of iron working in Zimbabwe to fully understand the spatiality of iron working as will be done in the following chapters.

Figure 7 **shows that fertility symbolism was expressed on pots, furnaces and items of dress (after Collett 1993)**



Technological studies

Stanley's (1931a, b) metallographic analyses of iron objects from Caton-Thompson's excavations at Great Zimbabwe mentioned earlier marked the first metallurgical investigations of products from the iron production cycle. With this early work on metallography, one would expect the proliferation of similar work which built upon Stanley's investigations but little research followed until the 1970s with Prendergast's work on different aspects of indigenous iron working in several localities in the country. Prendergast (1974) outlined the potential for iron extractive metallurgy in understanding the Iron Age communities of Zimbabwe. According to him, consideration of the technological aspects of prehistoric iron technology generated important data on how iron was worked over time and the place of iron production in the sub-continent. He also proposed that metallurgical studies of iron working yielded important information on the types of ores that were exploited, the methods of furnace operation, the use of fluxes, temperatures achieved in the furnaces and the efficiency of the process. Furthermore, Prendergast posited that combining metallurgical information with that gathered from other fields such as history and ethnography helps to shed light on the under-researched field of indigenous iron working. Despite this ground breaking paper, neither Prendergast nor later researchers followed up his ideas; his later work tended to focus on descriptions of furnaces and slags with a total absence of laboratory investigations.

Using standard metallographic procedures, Childs (1991d) analysed utilitarian and ceremonial objects from excavations carried out by Gilbert Pwiti and Robert Soper from Wazi Hill and Zvongombe South in northern Zimbabwe. The object of her analyses was "to determine if different techniques of manufacture or different degrees of skill were used on making utilitarian and ceremonial objects" (Childs 1991d, p. 3). She concluded that the time and effort that prehistoric smiths applied on different suites of objects was directly related to use and function. There was a disparity in the way items for everyday activities and ceremonial objects were made; ritual axes exhibited greater variability in their carbon content and were made of poor quality iron which limited their use in everyday activities such as cutting and chopping. In contrast, utilitarian objects were made from low carbon steels which were welded and work hardened to improve their performance in their intended purposes. Thus metallography demonstrated that prehistoric smiths understood the properties of their metals which they forged and manipulated to meet different functional needs.

Attempts to marry technological and symbolic aspects

Using metallography and the context in which metal objects were retrieved, Childs and Dewey (1996) analysed several objects from elite sites in Zimbabwe such as Khami and Great Zimbabwe and compared them with items from DRC to determine their use or function. Metallography showed that utilitarian objects such as axes and hoes were fabricated in a different way from non-utilitarian ones. For example, while utilitarian objects from both Zimbabwe and DRC were very thick and had use wear patterns, non-utilitarian objects were relatively thin and were devoid of such patterns. In addition, ceremonial and expressive objects were also aesthetically pleasing when compared to utilitarian objects. The expressive objects from Khami were recovered from the Hill Complex which is believed to have been the residence of the king (Huffman 1996, 1986). Contextually, this demonstrated their link with the leadership at the site. Metallographically, these contrasted with utilitarian hoes and axes from middens excavated at the site. Some of the utilitarian tools showed metallographic evidence that they were quenched in water whilst they were still red hot. In contrast, expressive items were allowed to cool slowly without any deliberate heat treatment.

Conclusion

Until recently, most iron working sites in Zimbabwe were studied by non-metallurgists whose interest lay in other artefact suites such as pottery (Chirikure 2005). Most of the work carried out so far on iron production is geographically isolated and sporadic making it difficult to understand the processes of iron working in different sites and regions. However, an attempt can be made to identify patterns and trends and in so doing evaluating the development of iron working through space and time. Archaeological sites dating to the Early Iron Age such as Mabveni have yielded the earliest known evidence of iron working in Zimbabwe (Robinson 1961b). Other EIA sites such as Kadzi, Surtic Farm, Tafuna Hill, Makuru, Malipati Dip and the Place of Offerings have produced remains of iron working. Most of the material from these sites was not studied from a metallurgical view point. However, the visual analysis of slag from Surtic Farm has identified the existence of slag tapping in the terminal Early Iron Age. Whether this intentional removal of slag from the furnaces was practised throughout the Iron Age is not known and only detailed diachronic studies can shed more light on continuity and discontinuity in the traditions of iron working. In addition, that no finds of furnaces have been reported has made it difficult to gain an insight into the types of furnaces used in the first millennium AD.

The existence of both natural draught and forced draught furnaces indicates the use of different types of furnaces in Zimbabwe's iron working past. While this may point to changes in furnace types over time, we do not know what prompted such innovations. Was it the need for efficiency which led to experimentation through trial and error or do they represent technologies borrowed from elsewhere? Obviously, to comprehend these issues further, technological developments must be interpreted in relation to economic and socio-political circumstances of the time. The archaeological correlates of iron working become abundant from the middle of the 15th century with most sites producing evidence of iron working. Apparently, the iron was produced in predominantly very small low shaft furnaces powered by bellows. This type of furnaces contrasts with the earlier ones which were large and may have been operated by natural draft as Prendergast (1983) has suggested. There is major need for detailed technological studies of ferro-processing evidence in order to reconstruct the technology of iron working in the Iron Age of Zimbabwe. At the moment the interpretation of the metallurgical information is at best speculative because it is not based on laboratory analyses. This will make it possible to situate continuities and discontinuities in iron working in the long term. Besides, the types of ores used and other metallurgical parameters are not well-documented indicating the need for more research in these areas. While observations on secondary smithing of objects have been partly covered in ethnographic studies not much is known about the archaeological correlates of primary smithing. Thus the reconstruction of the whole process of iron production including the decision making processes involved is an absolute necessity to improve our knowledge on how iron was worked in the past. The richness of the ethnographic and archaeological record of iron working suggests that in-depth research can produce valuable information. To consider that we need to study ethnographic accounts and the archaeological evidence to explore the trends in iron working as well as reconstructing the ideo-technical data. The next chapter explores indigenous iron working among the Njanja of south-eastern Zimbabwe, the Karanga of Chivi and the Kalanga of the Matopos area to evaluate if there is variation within the historical period.

Chapter Four: Ethnographic Accounts: Njanja, Karanga and Kalanga iron production in the late 19th and early 20th centuries

Introduction

The first strategy in developing a long term perspective on indigenous iron production was to evaluate the ethnographic record of iron working among the Njanja of Chikomba District, Karanga of Shurugwi and the Kalanga people of south-western Zimbabwe **(Fig 8)**. These communities were still producing iron in the early years of colonialism (Bent 1892, Franklin 1945, Hatton 1967, Headman Mubaiwa pers. com. 2004, Headman Ranga pers. com. 2004, Knight-Bruce 1896, Posselt 1926). They had contact with European observers who recorded crucial aspects of their iron working. Njanja elders still remember vividly how iron was worked in the early decades of the twentieth century (Headman Ranga pers. com. 2004, Munjayi Ranga pers. com. 2004, Nobert Ranga pers. com. 2004). Such information encompasses the *chaîne opératoire* of iron production from resource selection, the process of smelting, smithing and the distribution of the finished products. It must be emphasised that this exercise was not meant to generate models for interpreting the past but instead to highlight historically attested examples of variation in iron working. These groups were selected primarily for two reasons: they are all Shona societies with a putative common origin (Beach 1980, 1994, Bourdillon 1976, Robinson 1966) and they were making iron using indigenous methods in the late 19th and early 20th centuries.

Remarkably, while the principle of the process was similar, there were apparent differences regarding furnace types; the Njanja operated conical furnaces that were decorated with breasts (Mackenzie 1975), whilst the Kalanga used oval furnaces which were not decorated (Cooke 1966, Hatton 1967). The Karanga of Nhema, Shurugwi utilised bowl furnaces (Prendergast 1972). While Njanja iron working was large scale and geared towards meeting the demands of intra-regional trade (Mackenzie 1973, 1974a, 1975, Roger Ranga pers. com. 2004), iron working among the Karanga and Kalanga was for local use (Hatton 1967, Robinson 1966). Also, it would be interesting to study Kalanga iron working and evaluate how similar or different it is from Karanga and Njanja who were not influenced by the Ndebele's arrival in the 1830s.

Figure 8 **Map of the Zimbabwe Plateau showing the location of the groups of people studied**

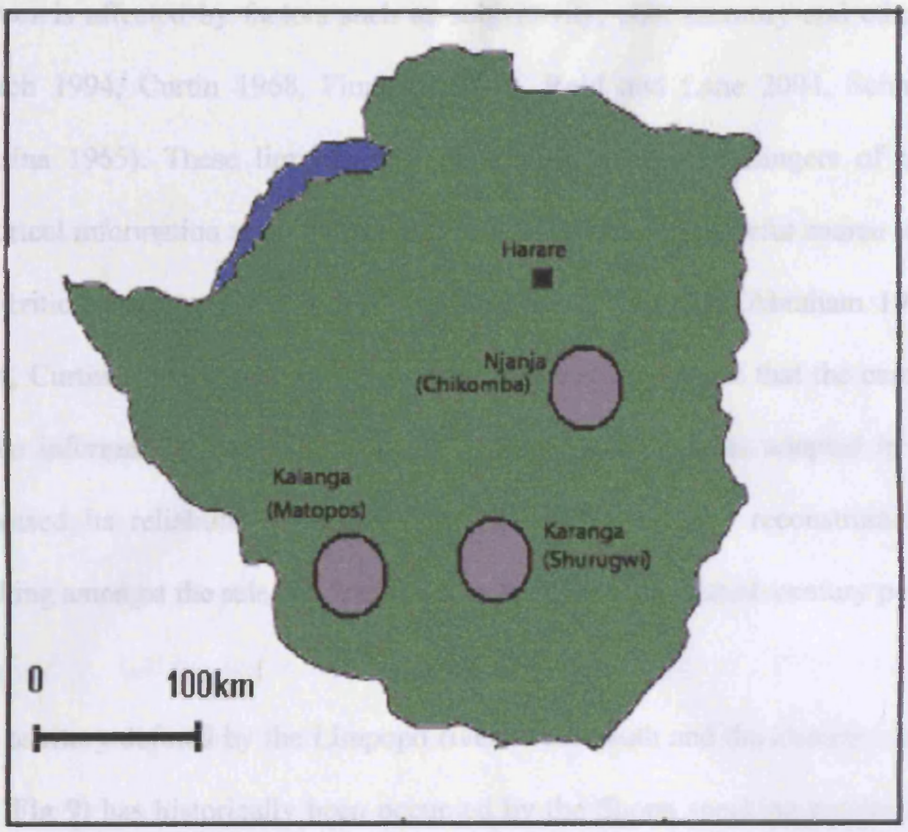


Figure 9 Map of Zimbabwe showing the research areas.

Background information

For the Njanja, oral interviews were conducted over three seasons of fieldwork (totalling eight weeks) among the Ranga and Kwenda people known to have exhibited their mastery of indigenous iron smelting at several shows in Harare until the 1970s. The interviews were supplemented with documentary evidence and ethnographic observations recorded by colonial administrators such as Posselt, the Native Commissioner of Enkeldoorn and Charter Districts (now Chivhu and Chikomba respectively).

Primary and secondary sources consisting of published materials and archival records were utilised in understanding Karanga and Kalanga iron working. The strength and validity of arguments used to interpret or explain the past using different historical sources is affected by factors such as subjectivity, poor memory and ethnocentrism (Beach 1994, Curtin 1968, Finnegan 1970, Reid and Lane 2004, Schmidt 1983, Vansina 1965). These limitations warn researchers of the dangers of taking any historical information at face value. However, rigorous and careful source verification and criticism can create a more balanced view of the past (Abraham 1959, Beach 1994, Curtin 1968, Vansina 1965, 1985). Hence it was hoped that the careful sifting of the information from both secondary and primary sources adopted in this study increased its reliability and credibility leading to a better reconstruction of iron working amongst the selected late nineteenth and early twentieth century peoples.

The territory defined by the Limpopo river to the south and the Zambezi to the north **(see Fig 9)** has historically been occupied by the Shona speaking peoples who have formed the largest single cultural and linguistic entity in the region for over 500 years (Beach 1980, 1994, Bourdillon 1976, Pikirayi 1993, Pwiti 1996). In addition, the Shona also exist in considerable numbers in parts of Mozambique and even extend into northeastern Botswana and south-western Zambia. An appraisal of the history of the region manifests that this Shona sphere of influence was heavily contested with states rising and falling while different groups of people sought to subjugate and dominate one another to acquire arable land as well as access to strategic resources (Abraham 1959, Beach 1994, Mudenge 1988, Pikirayi 1993, 2001). Such contestations fuelled massive population shifts to and from the Zimbabwe plateau from time to time as the politics and economic circumstances changed. Iron production and use was no doubt crucial for the gestation of these developments in as far as it enabled the production of basic tools from hoes for tilling the land to weapons for territorial expansion and consolidation (Beach 1980, Bourdillon 1976, Robinson 1966).

The Kalanga are a group of Shona speakers who were assimilated by the Ndebele when the latter settled and imposed their influence in south-western Zimbabwe in the mid-19th century (Beach 1980, Mudenge 1988, Robinson 1966). By the time of Ndebele occupation, there was a political vacuum in the area caused by the demise of the Changamire-Rozvi state based at Danamombe. Having accepted Ndebele hegemony, these Shona groups were expected to fulfil various obligations for their overlords such as paying tribute in the form of iron spears and axes (Mackenzie 1973, 1974, Robinson 1966). The Ndebele state had considerable iron requirements which were met through tribute and it is not surprising that the Ndebele exploited the Kalanga iron production for their own ends just as they embraced their religion and rainmaking shrines in the Matopos (Robinson 1966). It is thus important to study Kalanga iron working and evaluate how it was similar to or different from that of the Karanga of Shurugwi and Njanja who were outside immediate Ndebele control.

According to oral traditions, the Njanja made their appearance in the late 17th century, a period of great population convulsions in south-eastern Zimbabwe (Beach 1994, Mackenzie 1975, Mtetwa 1973). During the same time, the Mbire (part of the Shona) were drifting southwards from the north while the Hera (also Shona) were penetrating the plateau from the south. The Njanja, a highly specialised iron working group emerged in the midst of these population movements. They settled in the area around the present day Nharira area (part of Chikomba District) which was adjacent to the Mbire and Hera polities and in close proximity to the famous iron mines on the

Wedza Mountains. In due course from the late 18th century, the Njanja were popularly known as skilled smelters and smiths identified with the Wedza ore (Mackenzie 1975, Prendergast 1974, Schimmin 1893). It has been suggested that the Njanja were originally attracted to the area because of the iron ore deposits of the Wedza Mountains. However, Beach (1994) argues that the need for arable land may have been the driving motive for Njanja settlement for it seems that only those lineages such as Ranga and Kwenda that were close to the Wedza ore body were renowned for their iron working exploits. Apparently, the Njanja were by no means a powerful military entity to fight for land as the Hera and Mbire were always doing (Mackenzie 1973, 1975). This is evidenced by the fact that they virtually lost in all the wars which they fought with their neighbours the Mbire and in the process failed to assume direct control of the Wedza iron mines. Instead, they forged diplomatic alliances with the Mbire to have unlimited access to the ore. Conflicting as this may sound, what is indisputable is that on the eve of colonisation, the Njanja were famous for their skill and enterprise in iron production a fact that recurs in many ethnohistorical documents (Franklin 1945, Knight-Bruce 1896, Mackenzie 1973, 1974a, 1975, Posselt 1926, Schimmin 1893).

With the fragmentation of the once mighty Changamire-Rozvi state in south-western Zimbabwe, some of the groups which were once part of the state took advantage to assert their independence (Beach 1980, Robinson 1966). To this generalisation, the Karanga of Shurugwi, south-central Zimbabwe are no exception. Unlike the Kalanga, they did not fall into the area under the direct influence of the Ndebele's political hegemony though they may have been raided from time to time (Beach 1980, Robinson 1966). Karanga smelters and smiths exploited locally available ores but with time they smelted Wedza ore obtained through trade with Njanja entrepreneurs. It would be interesting to establish whether they also embraced Njanja iron working methods to increase output or just adhered to their own ways of producing iron.

It was hoped that the information emanating from the three case studies would generate data essential for understanding the different facets of pre-colonial iron production. The data was synthesised and compared to situate the patterns and variation in iron production in the closing decades of the late nineteenth and early twentieth centuries. With the limitations of primary and secondary sources in mind, an appropriate ethnographic approach was designed to ensure that the maximum amount of correct and reliable information was obtained to understand iron working among these historical communities.

The Ethnographic Approach: oral traditions, direct historical testimonies and ethnohistory

Ethnography is the study of people in their natural settings, their technologies, social life and culture based on qualitative methods such as detailed observations, interviews, and the analysis of primary and secondary documents (David and Kramer 2001, Haaland 2004, Huffman 1996, Renfrew and Bahn 1991, Schmidt 1978, 1997). Ethnographic studies therefore open a window into many aspects of a society's life. For the purposes of this study, a holistic ethnographic study combining oral traditions, direct historical testimonies and archival research was conducted on the selected groups to gain an insight into pre-colonial African iron working. Oral interviews were conducted to record what remained of the knowledge of iron smelting among the descendants of the leading Njanja master smelters such as Headman Ranga. These interviews were aimed at deriving data from oral traditions and direct historical testimonies. Oral traditions are verbal testimonies transmitted from one generation to another by word of mouth, while direct historical testimonies refer to personal recollections by people who had participated and observed the process (Beach 1983, Curtin 1968, Finnegan 1970, Reid and Lane 2004, Schmidt 1983, Vansina 1985). Such interviews were targeted at people who were directly involved with iron smelting and smithing as well as those who had observed the process when it was conducted by master smelters. In this regard, testimonies by Nobert Ranga the eldest son of the late master smelter Headman Ranga were an indispensable data source. The incumbent Headman Ranga has kept most of the Njanja traditions regarding their origins and entrepreneurial acumen. In addition, oral data were obtained from elders who had observed the process of iron production without necessarily taking part in it.

As primary sources, oral traditions give a glimpse of life, economy and technology at the time or near the time of the event. However, some of the recollections from the elders were suspect as they failed to reveal crucial data on the technological and ideo-technical aspects of Njanja iron working. Some of the informants apparently suffered from memory loss as they had forgotten the names of trees used for charcoal production for instance. By critically evaluating the data sets and cross-checking them with other independent databases, these limitations can be overcome and in the process produce unbiased historical reconstructions (Curtin 1968, Finnegan 1970, Krech 1991, Schmidt 1983, Stoller 1994, Vansina 1985). The data emanating from direct historical testimonies and oral traditions were augmented with archival research on the observations made by early travellers and researchers in the Njanja country. Missionaries such as Schimmin (1893), Knight-Bruce (1896) and travellers like Bent (1892) recorded many important aspects, which can be used to reconstruct the whole iron working cycle as practised by the Njanja. Also, colonial administrators organised numerous exhibitions on traditional methods of iron manufacture featuring Headman Ranga one of the most celebrated Njanja master smelters (Franklin 1945). The details of the smelts were carefully recorded and deposited with the National Archives of Zimbabwe. On their part, written records are not impervious to biases, distortions and prejudices that bedevil other sources of historical reconstructions. For example, reports by early travellers are often exaggerated and most of them were written long after visiting the societies which they wrote about (Beach 1994, Curtin 1968, Finnegan 1970, Vansina 1965). To this end, some descriptions of iron smelting furnaces and smithing practices are greatly exaggerated and the reconstructions were often stage managed to suit the whims of the observers. For example Rickard (1939) published pictures of a series of Shona iron furnaces in operation yet those furnaces were replete with cracks making it difficult to believe that they had ever been used.

Primary and secondary sources were used to obtain information on Kalanga and Karanga iron working. Primary sources took the form of records by early twentieth century explorers and reports by some colonial administrators. These sources though largely descriptive contain useful data on several aspects of iron working from mining the ores through smelting to the use and discard of objects. Such information is deposited in the National Archives of Zimbabwe. Travellers such as Theodore Bent and Frederick Courtney Selous wrote about iron production as it was practised by different Shona societies in the late 19th and early 20th centuries. However, these late 19th century sources are heavily affected by European ethnocentrism that viewed several aspects of African lives which they did not comprehend with contempt. Consequently, they must be carefully studied to extract such biases which coloured their interpretation of indigenous cultural practices. These reports are also complemented by scholarly texts written by academics from the middle of the 20th century. With the data from his informants, Prendergast (1972) organised a smelting reconstruction where he recorded the most essential aspects of indigenous iron working among the Karanga of Shurugwi. Similarly, Hatton (1967) conducted an ethnographic study among the Kalanga of the Matopos just as Mackenzie (1973, 1974a, 1975) reconstructed several aspects of Njanja iron workers. While these secondary sources suffer from the handicap that they were authored decades after the original events and in some cases after the experts had all died, they were written by academics who were trained in scientific methods of source verification and criticism. In this context, the different categories of data utilised in this study were logically and rigorously analysed to deduce more than what they said at face value (Beach 1994, Curtin 1968, Finnegan 1970, Vansina 1985,) before any conclusions were made thus making sure that they were reliable data sources.

Schmidt (1978, 1983, 1997) has shown the efficacy of combining oral historical evidence with documentary evidence in reconstructing prehistoric iron working. After consulting early documentary sources on iron smelting and smithing in Tanzania, Schmidt (1997) came across a picture of iron smithing which depicted a small forge surrounded by more than ten men. Doubting the picture, he consulted oral traditions to establish its authenticity. After carefully sifting the oral sources, Schmidt discovered that the forge was operated by not more than four people thus exposing the bias inherent in the picture. This shows that careful and rigorous evaluation of sources can lead to unbiased representations of ancient technical systems. Whatever the weaknesses of these methods, when combined, they provide an external as well as an insider view of iron working leading to a fuller reconstruction of the whole production cycle (Childs 2000, Krech 1991, Schmidt 1983, Stoller 1994) elucidating issues such as innovation and technological transfer between different groups of people.

The rocks that make iron: mining the ore

Iron production depended on the selection of suitable ores for reduction in the furnaces (Headman Ranga pers com. 2004, Nobert Ranga pers com. 2004, Samaita pers com. 2004). This usually involved important decision-making processes since some ore bodies possess distinct metallurgical advantages over others (Friede and Steel 1977, Miller *et al* 2001, Miller and Killick 2004, Prendergast 1974). In the case of pre-colonial Njanja iron working, a single type of ore was historically linked with the smelters (Mackenzie 1975, Prendergast 1974). Generations of Njanja smelters thrived on exploiting the banded iron stone from the Wedza Mountains about fifty kilometres away from their territory (Headman Ranga pers com. 2004, Mackenzie 1975, Munjayi Ranga pers com. 2004, Nobert Ranga pers com. 2004, Samaita pers com. 2004). Stretching for twelve kilometres from the northeast towards the Save River in the southwest, the Wedza Mountains consist of pre-Cambrian schists. Geologically, these schists are known to contain highly permeable and easily reduced iron ores (Prendergast 1974). Though pre-colonial smelters may have had no idea of the chemistry of the ore, they had mastered its advantages over other types of ore in the area. It is therefore not surprising that from the settlement of the Njanja in the area up to the present, their iron working industry has been exclusively associated with the haematite from Wedza (Headman Ranga pers com. 2004, Mackenzie 1975, Munjayi Ranga pers com. 2004, Nobert Ranga pers com. 2004, Samaita pers com. 2004). Also, that a distance of more than fifty kilometres separates the Wedza Mountains from the furthest of the Njanja polities did not act as a deterrent to smelters though some of them had settled near the ore source by the turn of the twentieth century.

The metallurgical analyses of the ores carried out by the early mining groups who wanted to exploit them for modern iron production in the early 20th century demonstrated that they contained in excess of 60 percent iron oxide content though it could be easily upgraded through beneficiation to about 90 percent (Mackenzie 1975, Prendergast 1974). During the smelting season, scores of Njanja men and women thronged the mines of Gandamasungo and Chipangure for ore extraction under the supervision of experienced males who were not necessarily master smelters (Headman Ranga pers com. 2004, Mackenzie 1975, Munjayi Ranga pers com. 2004, Nobert Ranga pers com. 2004, Samaita pers com. 2004). After sufficient ore was mined, it was packed into sacks and transported on the back of oxen to the Njanja country for the smelting activities. Njanja mining operations were not subject to rituals and taboos that exclude social groups such as women in other communities such as the Karanga of Chivi in south-central Zimbabwe (Bent 1892), the Toro of Uganda (Childs 1998, 2000), and even the Bahaya and Fipa of Tanzania (Barndon 2004, Schmidt 1997). Contrary to this, able-bodied Njanja women of all ages participated in the mining operations from the selection of ore to its drying (Mackenzie 1974, 1975, Nobert Ranga pers com. 2004). As will be shown later, their labour was vital in the intensive market-oriented Njanja iron production. Upon arrival, the master smelter sorted the ore into groups of high and low-grade ore. In the end, the two groups were mixed and dried ready for reduction in the furnaces as no roasting was done prior to smelting. Some of the ore was packaged and subsequently found its way into the intra-regional trade networks where it was exchanged for goats and in some cases cattle. As indicated by travelling long distances to mine the ores and in some cases fighting bloody wars to gain access to the iron mines (for example against the Mbire in the early 19th century), it can be argued that the Njanja had preferred the properties and merits of the Wedza ore. The fame of the Wedza ore is well documented (Knight-Bruce 1896, Mackenzie 1975, Prendergast 1974) and some groups of smelters who lived as far away as Shurugwi about one hundred and fifty kilometres away obtained the ore through Njanja traders. It is claimed that the Njanja had itinerant smiths who travelled to areas such as Gutu in the south, smelting the ores and selling their products there (Headman Ranga pers com, Mackenzie 1975).

In Shurugwi haematite was surface collected by Karanga master smelters in the areas adjacent to the village. The great uncle of one of Prendergast's (1972) informants VaJangwa obtained such ores from the nearby Zinhedzi Mountain. This local ore was blended with that obtained from Lalapanzi a district thirty kilometres away. However, in some cases Karanga head smelters imported the ore from Wedza. Karanga men could travel to the Njanja country to obtain the ore in exchange for cattle and goats. The great distances which the Wedza ore was carried in the last 150 years indicates that iron smelting may have been carried out in areas possessing no sources of ore (Prendergast 1972). This is possible because the demand for iron in some societies was limited and almost constant over time. Such areas only conducted small and infrequent smelts when compared with areas that had high demand where production was constant over long periods of time. The Kalanga of the Matopos area smelted laterite and magnetite sands to produce iron for their needs that included paying tribute to the Ndebele even though banded ironstone was available (Hatton 1967).

Charcoal Preparation

Choosing fuel with a high calorific value was very important and as such not every tree was used for charcoal production. According to Nobert Ranga, Njanja iron smelters selected woods, which were not generally considered for domestic purposes such as cooking in the homesteads. Thus Njanja and Karanga smelters and smiths exploited deciduous hard woods such as *Burkea Africana (mukarati)*, *Monotes Engleri (mushava)* and *Pericopsis angolensis (muvanga)*. However, *Julberdia globiflora (munhondo)* was popular among the Kalanga though by no means the only tree exploited (Cooke 1966, Hatton 1967). In metallurgical activities, the major advantage of such hard woods is that they burn slowly and in the process produce much heat for longer periods of time. The production of charcoal among the Njanja involved the dry distillation of wood, a process by which wood is partially burnt in an oxidising atmosphere and then covered with sand to char in a reducing environment. The Karanga process differed from that of the Njanja in that the burning wood was drenched with water instead of being covered with sand (Prendergast 1972).

The Karanga collected their charcoal from a distance of only one mile from the smelting site, a practice that was also common among the Kalanga of the Matopos (Prendergast 1972, Hatton 1967). During the periods of intensive iron extractive operations in the Njanja iron industry, charcoal production was conducted on the smelting site (Mackenzie 1974a, 1975). The Njanja ironworkers alleviated the labour shortages emanating from the demand for more manpower in the production of charcoal by employing women to assist in the process. Women could burn the wood, make the charcoal and ferry it to the "factory".

Clay selection, building furnaces, tuyeres and bellows.

The furnace was constructed under the direction of the master smelter (Bent 1892, Franklin 1945, Goodall 1944, Hatton 1967, Mackenzie 1975, Prendergast 1972). A good furnace could withstand the temperatures involved in several years of smelting without crumbling. Thus the furnaces were intended for re-use over a number of smelting episodes. Selection of suitable clays that achieved the twin aims of maintaining the mechanical integrity of the furnace and heat containment was a challenge facing master smelters who took care of all the steps leading to the construction of the furnace from clay prospecting and selection to the building of the furnace (Goodall 1946). Obviously, not every type of clay was appropriate for making furnaces. As such master smelters usually prospected for suitable clays and at times the right clay could be found at a distance of up to ten kilometres from the smelting area (Prendergast 1972).

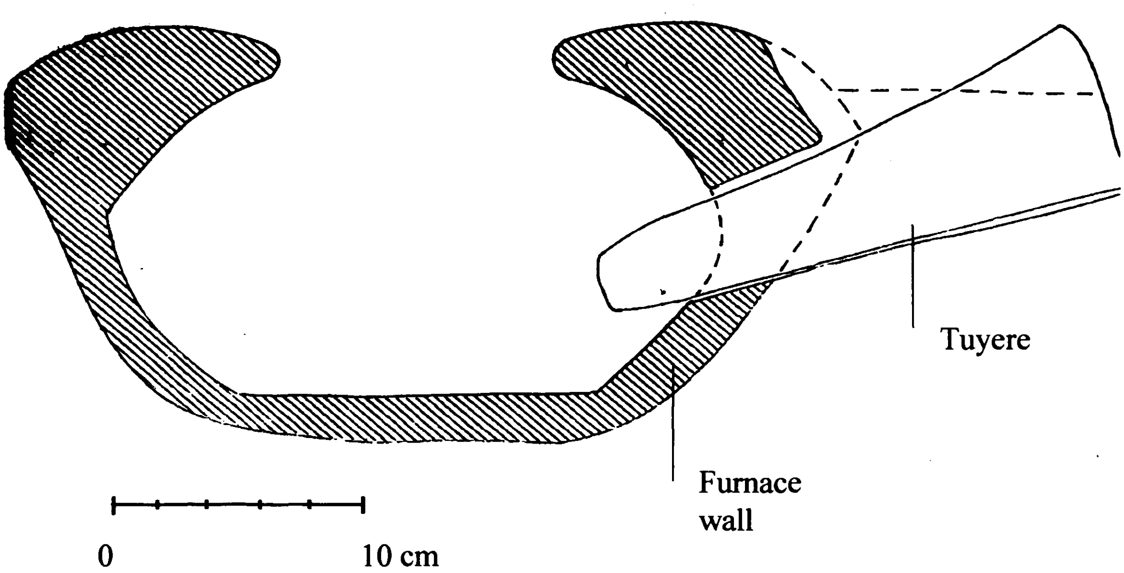
The Njanja smelters utilised those special clays *(rondo)*, which would not crack when dry while at the same time sufficiently strong to withstand several seasons of smelting. Among the Njanja, the selection and preparation of clay was the preserve of men (Headman Kwenda pers com. 2004, Munjayi Ranga pers com. 2004, Roger Ranga pers com. 2004, Samaita 2004). The Njanja clay *(rondo)* was tempered with grains of collapsed furnaces (grog) to strengthen it (Mackenzie 1975). This increased the strength of the Njanja smelting furnaces which were utilised for long periods of time.

Among the Karanga (Shurugwi), Prendergast (1972) reported that the clay used to construct furnaces was taken from a pit where potters also extracted their clay. The excavation of the clay was ritualised and fell within the remit of women who were potters. It was believed that any involvement of men could cause the furnace to crack afterwards. However, it is not clear whether ancient Karanga smelters also used clay dug by women or it was a 20^{th} century development. The clay was broken down into small pieces and ground until a very fine texture was achieved. It was then mixed with water until the required plasticity was reached. After this meticulous preparation of the clay, it was left overnight with furnace construction starting the following day under the supervision of master smelters. The construction of furnaces involved piling up panels of clay and then shaping them to achieve the desired shape (Goodall 1944, 1946).

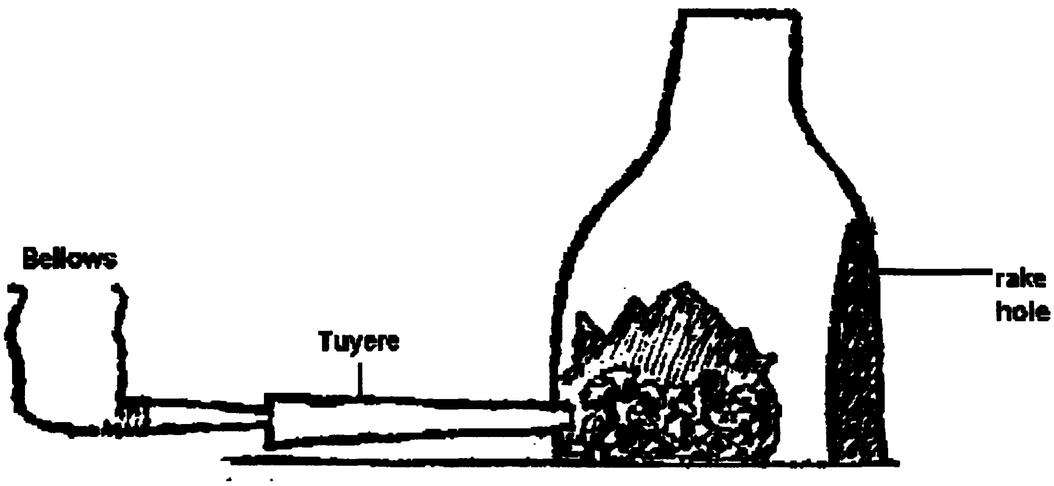
Decorations in the form of breasts, tattoo marks and female genitalia were applied after the whole structure was completed in the case of the Njanja and Karanga while Kalanga furnaces were not decorated.

The open-bowl furnace of the Karanga of Shurugwi had one tuyere hole while Kalanga furnaces had two tuyere holes as compared to four to six for Njanja furnaces. When completed, Njanja furnaces were conical, approximately 120 cm high and 100 cm wide at the bottom (Franklin 1945) and breasted (Mackenzie 1975). Kalanga furnaces were oval and smaller with a height not exceeding 90 cm and a width of 60 cm at the base (Hatton 1967).

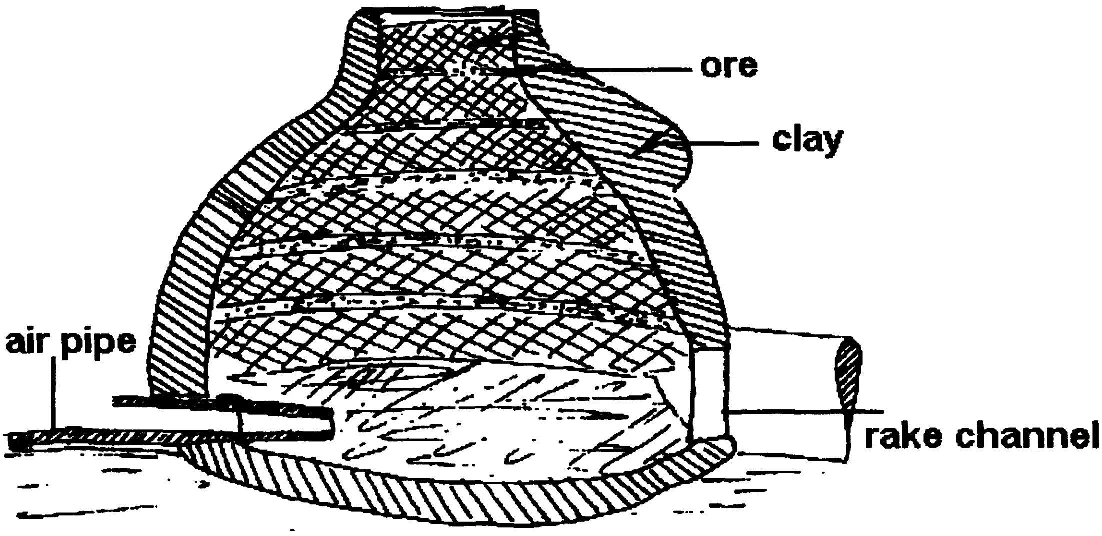
Figure 10 **Schematic representations of ethnographic iron smelting furnaces**



a. Karanga iron smelting from Shurugwi (Prendergast 1972)



b. Kalanga Iron smelting furnace in the Matopos (Hatton 1967)



c. Njanja iron smelting furnace (Brown 1973).

Tuyeres to supply combustion air to the furnaces were also constructed using clays. The available evidence indicates that similar clays were used to build both furnaces and tuyeres amongst the groups that were studied. At the Salisbury demonstration of 1972, the Njanja master smelter Ranga used the same type of clay to construct the furnace wall and the tuyeres (Brown 1973). In western Tanzania, Childs (1989) has noted that clays that were used to make tuyeres were more refractory than those used to make the furnaces. This is because tuyeres were supposed to keep on supplying the air throughout the smelt and failure to do so would prematurely terminate the process. However, the corrosion of the tuyeres in some instances helped in the slagging process (Joosten 2004, Miller 1997, Miller and Killick 2004, Rostoker and Bronson 1991). It could not be established whether tuyeres used in all the three areas were tempered or not. The tuyeres were usually made after the furnace was built in the Njanja area while the Karanga insisted that it was always important to make the tuyeres and bellows first. Perhaps this demonstrates differences in choices between different groups of people. However, in all cases tuyere construction involved the plastering of clay over a long wooden stick. The stick was then pulled out leaving a four to five centimetre diameter hole. The tuyeres were then flared at the end to accommodate the goatskin bellows and left to dry.

Another important iron working installation made of carefully selected clay was the smithing hearth or *chido*. The Njanja smithing hearth was smaller when compared to iron smelting furnaces. Its height averaged between ten and fifteen centimetres above the ground. The end with a blowing hole was made slightly higher in order to protect the bellows from the heat. The hearth was built adjacent to the smelting furnaces to take advantage of the residual heat from the smelting process (Mackenzie 1975). The bloom was removed from the furnace and immediately placed into the nearby smithing hearth where it was consolidated into usable iron and transformed into tools. Normally, the Njanja blooms were big enough to make four or five hoes (Goodall 1946). Unfortunately, not much information is available on the smithing hearths used by the Kalanga and Karanga groups.

Goatskin bag bellows were used to generate the air blast for smelting and smithing. The making of bellows was a specialised activity that required experienced personnel to make sure that not many openings were left on the skin (Goodall 1946, Headman Ranga pers com. 2004). The skin was worked so that it could become supple. The making of bellows was considered a very important part of Karanga smelting. If they were good, the smelt would not fail (Prendergast 1972). The different types of furnaces determined the number of bellows which were used and some tuyeres could be closed and reopened when the need arose. The bowl furnaces of the Karanga employed a single pair of bellows for one tuyere, just as among their Kalanga counterparts (for two tuyeres) (Cooke 1959, Hatton 1967). Two to three pairs of bellows for four to six tuyeres operated by two/three people were used by the Njanja. The bellows operators regulated the air inflow into the furnace by increasing or decreasing the stroke depending on the instructions from the master smelter (Goodall 1946).

Iron smelting in the late 19th and early 20th centuries

When all the necessary preliminaries in the iron production cycle were completed, the process of smelting began. Initially, the master smelter arranged the tuyeres in their proper positions in the furnace and usually they were placed on top of the charcoal bed. The furnace was preheated with logs and charcoal to drive away any moisture before use. Immediately, the charge was added into the furnace in alternating layers of ore and charcoal while the bellows generated the air blast. The ratio of ore to charcoal could not be established but at one smelting demonstration held at the Queen Victoria Museum in Harare by Headman Ranga; one handful of ore was followed by four handfuls of charcoal (Brown 1973, Franklin 1945). The ore was roasted as it drifted from the top of the furnace towards the reduction zone (Prendergast 1972). The master smelters kept an eye on the air supply during the whole process ordering bellows operators to either increase or slow the blowing rate depending on the stage at which the smelt was (Goodall 1944). Thus one pair of bellows could be operated when it was felt there was enough heat in the furnace. Constant attention was given to tuyere performance to prevent them from blocking. Traditional songs and dances were often performed to help keep the bellows rhythm constant and as part of the entertaining process. Both men and women participated in the process.

In the Karanga bowl furnaces, smelting was usually completed after two hours though of course the bloom was very small just enough to make a single hoe. Oral data concur with archival documents on the assertions that the Njanja smelt was terminated after six or seven hours after which the bloom and slag were removed (Mackenzie 1975). Usually the slag would have reached the tuyere level such that smelting could not be continued without them clogging. The furnaces used by the three groups were non slag tapping. Njanja and Kalanga furnaces were designed to permit the removal of the bloom through the rake channel on the side so that smelting could resume whilst the furnace was still hot. The liquid slag flowed from the furnace while the bloom was removed using tongs made of tree bark. Initially, fragments of slag adhering to the bloom were knocked off and the bloom was either smithed immediately or reserved for use during the rainy season when agriculture was the dominant pre-occupation (Munjayi Ranga pers com. 2004, Nobert Ranga pers com. 2004). The furnace was cleaned and minor repairs were made before the furnace could be re-used again. It seems that little damage was made on the furnace wall for often one smelt could immediately follow another one without reheating the furnace. In times of high demand for iron, up to twenty furnaces or more were operated simultaneously by the Njanja who recruited a large pool of apprentices to assist with pumping the bellows and other menial tasks (Headman Ranga pers com. 2004, Mackenzie 1975). There is no evidence for round the clock iron smelting in other areas except among the Njanja who employed a shift system of labour (Headman Kwenda pers com. 2004, Mackenzie 1973, 1974a, 1975, Samaita 2004).

The smelting reconstructions conducted by the Ranga people of Njanja and those organised by Prendergast (1972) among the Karanga in Shurugwi are very important in illuminating several aspects of indigenous iron smelting. While Headman Ranga continued to smelt from the early 1920s until the 1970s when he died, neither of Prendergast's informants had done that. The result was that all of Ranga's demonstration smelts produced forgeable and usable iron while those of VaJangwa (Karanga) failed to produce any metallic iron though there was some liquidation of the slag. Another important factor apart from the lack of practice is that the Shurugwi re-enactment furnaces were not operated using local ore, but rather a high grade ore from Buchwa close to a hundred kilometres away. This reinforces the point that different smelting technologies were designed to cater for specific ores. However, despite the fact that the smelt was a failure, the Karanga informants appreciated the whole process of iron production using indigenous methods which strongly suggests that their recollections of what they saw can be trusted (Prendergast 1972).

Iron smithing

The red-hot bloom from the smelting furnace was often immediately worked in the smithing hearth to remove occluded and adhering slag thus converting it into usable iron (Brown 1973). Then, the billet was repeatedly heated and hammered on the stone anvil using hammerstones to achieve the required shape of the object. Examples of the objects made by smiths in all the research areas include hoes, spearheads, ceremonial axes and arrowheads (**see Fig 11**). In the process, some of the slag settled at the base of the hearth and assumed the shape of a bun on solidification. Around the anvil, slag prills and hammerscale were scattered. Njanja master smelters were very skilled blacksmiths who were responsible for the final shaping of tools with the apprentices having done the rough work (Goodall 1946). According to Hatton (1967), the Kalanga smiths in the Matopos used ground smelting slag as a flux in welding two pieces of iron together when making larger objects such as hoes, a practice observed among the Njanja. The workmanship of smiths differed and it is not therefore surprising that the Njanja iron products were highly valued in most areas of the Zimbabwe plateau even though such areas had their own smiths. Like the Njanja, the Kalanga smiths also quenched the finished objects in cold water and in some cases non-utilitarian objects were left to cool slowly.

During the process of data collection, I participated in the forging of one hoe and a ceremonial axe using scrap iron in a traditional Njanja hearth operated by Munjayi and his son Roger. The smithing hearth was made of *rondo* clay in a manner reminiscent of the great Ranga iron workers. The forge had a height of between ten and twenty centimetres above the ground. Inside it had a sump where slag and charcoal collected. The two smiths had operated the hearth continuously for close to ten years. However, the major difference with the historic Njanja hearths was in the area of air blast. While pre-colonial smiths employed goatskin bellows, Munjayi and Roger employed a fan driven by a belt connected to a bicycle hub. After lighting the fire using logs, charcoal from hard woods was charged into the hearth and with continuous blowing, a good fire started to appear. Two pieces of wrought iron were heated to red hot and subsequently hammered on the anvil until the desired shape was achieved. The by-products of the smithing process such as hammerscale were clearly visible on the area surrounding the anvil. Very little slag had formed at the bottom of the hearth; the scrap iron is known to have very few slag inclusions and to give very little slag. The tools employed in the process include modern tongs and anvils which were used with great effect in producing the desired objects while earlier the Ranga demonstrators used dolerite hammers and anvils and goatskin bellows in order to achieve the same ends. However, by using new tools Munjayi is much more efficient in saving labour and the amount of products that he makes per day. For example, his mechanised air blast is very efficient and less labour intensive when compared to pumping bellows. These innovations illustrate how through borrowing techniques from others and modifying the process, smelters and smiths can improve the efficiency of their process easily. Munjayi and his son distribute their products in the neighbouring communities and they earn their living from their craft.

Rituals and taboos

In many pre-colonial southern African societies, iron smelting was accompanied by the use of medicines to protect the smelts from sorcerers whose actions allegedly led to the failure of smelts. In this connection, Njanja, Kalanga and Karanga smelters placed medicines in shallow holes at the bottom of their furnaces. Such medicines varied from society to society even though smelters were secretive about them.

The transformation of iron ore into a bloom in the furnace was a highly ritualised process (Childs 2000, Childs and Killick 1993, Collett 1993, de Barros 2000, Haaland 2004, Ndoro 1991). However, such rituals and taboos varied considerably with iron smelting being highly ritualised while smithing was comparatively less so. Oral traditions and ethnohistorical sources show that Njanja iron smelting furnaces (such as those used at the Harare demonstrations) were decorated with moulded anthropomorphic designs such as breasts and bodily modifications like tattoos. These fertility symbols resonated very well with those that appeared on material culture such as granaries, drums and even the pottery of most Shona speaking groups (Collett 1993, Mackenzie 1975). It can therefore be argued that the Njanja people shared the same worldview with the other Shona groups in which there was a metaphorical link between the smelting process and human procreation. The iron hoe was very important in all Shona societies for it was used as the payment for bride wealth amongst all the studied groups. Through inter-marriages, the Njanja built a very strong relationship with their arch-rivals the Mbire which ensured their access to the ores located in Mbire territory.

However, in as much as reproductive symbolism pervaded Njanja iron working, it was not characterised by the ritual seclusion of women as in the case of the Karanga of Chivi observed by Bent (1892). Collett's (1993) study (see Chapter 3) among the Karanga of south-central Zimbabwe demonstrated that smelters were supposed to abstain from sexual intercourse during the process of iron smelting. Also, women were barred from participating from the preparation of the smelt through the extractive process up to the distribution of the finished products. Iron processing was exclusively a male domain. This contrasts with the Njanja who as we have seen employed women in all crucial aspects of the process such as mining and beneficiating the ore and singing and dancing to entertain the smelters (Dewey 1991). This non-adherence to ritual was a very influential form of reorganisation of production that helped the Njanja to cope with the labour demands of their large scale production. As Mackenzie (1975) has put it, incorporating women in the production process helped the Njanja to overcome labour shortages thus enabling them to increase their output to cater for the demands of an ever expanding market. De Barros (2000) has also noted that in the market oriented iron production in Bassar, Togo, the labour of women was fundamental in increasing production and thus satisfying the needs of the consumers. That all sections of the population participated in the production process meant that the locations of Njanja iron industries were dictated more by the need for resources such as labour than by the need for secrecy or the rituals and taboos (Mackenzie 1974a, 1975). Hence Headman Ranga (pers com. 2004) vividly remembers that the much famed Njanja iron industry was located within the centre of the village at a place called Magangara some fifty kilometres away from the present Ranga area. Thus although symbolism was part of the Njanja cosmology, they were not impeded by rituals which denied smelters women's labour in some societies showing that though taboos played a significant socio-cultural role, they may have had no technological value.

It is worth repeating that among the Karanga of Shurugwi, women also participated in iron smelting through their involvement in clay extraction and preparation. In fact it was a taboo for men to excavate the clay for it was believed that the furnaces or tuyeres would crack. Hatton (1967) also recounts that women were involved in Kalanga iron smelting and in some cases they even pumped the bellows. Thus the variability of the issue regarding ritual and taboos in iron smelting among the Njanja and Karanga of south-central Zimbabwe highlights the dangers of making generalised interpretations on the basis of one study. This case also calls for the critical evaluation of the spatiality of iron production in the archaeological record in order to determine whether it was uniform or varied over time.

Distribution of the finished product

The Njanja people were specialised iron workers who produced a wide inventory of tools to satisfy the demands of an ever burgeoning supra-village market (Mackenzie 1975, Nobert Ranga pers com. 2004). Some of the products from their smiths include spears and arrows for hunting and hoes for cultivation **(see Fig 11)**. In addition, the Njanja were very skilled in mining ore which they traded alongside finished products with people as far south as Gutu and as far west as Shurugwi (Mackenzie 1975). The Portuguese from Sena also brought exotic goods like beads and even guns for trade in the Njanja country in return for locally produced iron. Groups of up to twenty Njanja men moved from one village to another exchanging their merchandise for goats, cattle and even wives (Headman Ranga pers com. 2004). In another dimension, young men from neighbouring areas also travelled from their villages and exchanged their labour for hoes which they could use to pay bride price when they eventually returned to their homes. Also, the Njanja had itinerant and specialist smiths who under the instructions from master smelters would travel long distances making iron and selling finished objects in the dry season when there were no farming activities. From the time when the Njanja settled in their heartland in the late 17th century up to the time of colonisation in the late 19th century, the fame of the Njanja iron industry had spread over wide areas of more than a two hundred kilometre radius (Mackenzie 1975).

Figure 11 **Objects made by Shona smiths (photographs taken with due permission from the Museum of Human Sciences).**

a. ceremonial axe

b. iron hoe

c. thumb piano

d. arrowheads and a spear head

Compared to the Njanja iron industry which catered for wider networks, the production of iron among the Karanga and Kalanga was rather local. In Shurugwi this is attested by the prevalence of bowl furnaces which produced very little iron. According to VaJangwa, Karanga smelters only produced iron when there was need or when requested to do so by a customer who usually resided in the same village (Prendergast 1972). The production of iron among the Kalanga was for local demand only although they were supposed to pay tribute to their Ndebele overlords using iron implements. From the available evidence, it seems that the tribute system did not alter the scale and method of organisation of Kalanga iron production (Prendergast 1974).

Smelter and the smith in society

As Childs (1991b) has noted, smiths rather than smelters were highly esteemed in many Shona societies. Quite interestingly though, master smelters were also master smiths which presumably explains the absence of a vernacular term for smelters (Childs 1991b, Mackenzie 1975). The smith or *mhizha* was thus famed more for the quality of objects from his workshop rather than the amount of iron that he produced during smelting. Among the Njanja, knowledge of iron extraction and smithing bestowed on individual smelters the opportunity to be at the nexus of economic, socio-cultural and even political events which was not the case in other areas where smiths did not get rich enough to have a position of dominance. Oral traditions and ethnohistorical sources are replete with evidence showing that the founders of several Njanja chieftaincies were master smelters and smiths (Beach 1994, Headman Kwenda pers com. 2004, Headman Ranga pers com. 2004, Munjayi Ranga pers com. 2004, Nobert Ranga pers com. 2004). Since iron smiths were well rewarded in that they obtained a lot of cattle, goats, sheep and even exotic items through exchanging iron objects in intra and inter-regional trade, they accumulated a lot of wealth which they used as a springboard to political power. In this connection, powerful Njanja chiefs such as Tambaoga, Ranga and Kwenda were leading iron smelters and smiths (Headman Ranga pers com. 2004, Headman Kwenda pers com. 2004). Ranga and Kwenda encouraged apprentices from neighbouring areas to come to their areas and settle thus providing more labour which was essential for their iron industries. In the end, the control of large numbers of people and the productive economy bestowed political power on leading entrepreneurs such as Ranga. This control of the productive base of the economy has stimulated the birth of social differentiation and the subsequent rise of chiefdom societies in other parts of the world such as Mesoamerica and Australasia (Hayden 1995, 2001, Flannery 1999). In the case of the Njanja, leading smelters controlled iron production and obtained wealth and in the process assuming a leading socio-political role in society. Thus unlike in some societies in Zimbabwe such as the Mutapa in the north and the Ndebele in the southwest where there was no connection between iron working and political power, Njanja smelters and smiths used their knowledge to gain political and economic ascendancy. Hence there was a relationship between chieftainship and metallurgical skill among the Njanja of south-eastern Zimbabwe. The late Headman Ranga (Zinwamhanga) argued that Njanja iron production was categorically linked to power relations in society since it was handed down for several generations by great smiths who were also chiefs and thus inspired their descendents from the spirit world (Goodall 1944, Mackenzie 1975).

This Njanja case varies considerably from the situation among the Karanga of Shurugwi and the Kalanga of the Matopos where there were no demonstrable links between iron smelting and smithing and political leadership. Prendergast (1972) also argues that though smelters and smiths were respected among the Karanga, they did not wield any political power and neither did the rulers in those areas claim any relationship with iron working. That iron production in the area was for local demand only suggests that Karanga smelters did not achieve any political status. Thus, amongst the Njanja, political power was a result of economic success which was a result of organisational skills and secondarily justified by spiritual links.

Summary

This ethnographic survey of iron working among selected groups in Zimbabwe has shown similarities and variation in a number of key areas. The production of iron in all cases was based on the solid state reduction of ores to extract metallic iron. However, the technology was adapted and expressed differently by the studied groups. There are major variations in the organisation and scale of production as well as in furnace types and their method of operation (**see table 1**). For the Njanja, it is clear that they adapted their *chaîne opératoire* to new possibilities ushered in by the rising demand for their iron. As shown in the table below, Njanja furnaces were more developed when compared to those used by the Karanga and Kalanga. For instance, Njanja furnaces utilised up to six tuyeres which contrast with the Karanga furnaces which used one tuyere and a single pair of bellows. These points of divergence in the technology appear to correlate with variations in the organisation and scale of production in the selected areas. The Njanja market-oriented economy demanded the use of multiple, large and efficient furnaces when compared to the localised nature of production among the Kalanga and Karanga. The emergence of specialist and itinerant iron workers among the Njanja indicates a form of reorganisation that was meant to maximise the returns for leading smelters. The Njanja industry was well ahead of its contemporaries and clearly shows that changes in the method of organisation can also lead to improved and efficient production without necessarily changing the basic technology (Mackenzie 1975). Significantly, the variation that was detected in this chapter shows that the notions of homogeneous iron working practices recorded by early travellers and missionaries at the beginning of the 20th century may not be valid. This demonstrates the need to understand iron production in the archaeological record and compare it with historical cases to determine if the technology changed or developed over time (see Chapters 8 and 9).

Table 1 below summarises the key features of early iron working as it was practised by the groups considered in this discussion.

Variable	Njanja	Karanga (Shurugwi)	Kalanga
Ore extraction method	Mining	Surface collection	Surface collection
Furnace Type	Conical	Bowl	Oval
Slag pit	Absent	Present	Absent
No of Tuyeres	Four/six	One	Two
Decoration	Breasts, scarifications	None	Breasts, scarifications
Taboos and rituals	Absent	Present	Absent
Location of smelting	Within villages	Outside villages	Within villages
Smithing hearth	Open hearth	Open hearth	Open hearth
Objects made	Hoes, axes, thumb piano keys, arrowheads, spears, ceremonial axes	Hoes, thumb piano keys, arrowheads, ceremonial axes	Spears, hoes, arrowheads, thumb piano keys, ceremonial axes
Smelters and smiths chiefs	Yes	No	Not known

Symbolism and rituals pervaded iron working among the studied groups. However, major variations have also been detected in this area. For example, while symbolism was part of their cosmology (as shown by anthropomorphic designs on furnaces), the Njanja were not inhibited by the taboos that excluded women and children in the production of iron. This is significantly different from the Karanga who excluded women from participating in the actual smelting activities despite using them to source the clay. This difference in the adoption of rituals also impacted on the spatial location of iron smelting furnaces. Because smelting among the Karanga was highly ritualised when compared to the Njanja and Kalanga, they located their furnaces outside settlements where women and children could not observe the process. Among the Kalanga and Njanja societies, however, women's labour was critical in areas directly related to smelting such as pumping the bellows. As such, their smelting was practised within the centre of villages where labour was available unlike in the Karanga area where rituals and taboos had an important part in the spatial organisation of the craft.

It is also of interest to analyse the remains from Njanja iron production to compare with samples from the archaeological record in order to identify similarities and differences. This creates an understanding of the evolution of smelting practices over time elucidating on issues such as transmission of production methods and innovation over time. Guided by oral traditions, one extensive site of Njanja iron working located on the base of Gandamasungo Mountain in Wedza was studied in detail (Chapter Six). Samples consisting of remains of ore, broken tuyeres, slag and possible smithing hearth bottoms were collected for laboratory investigations.

With this variability in the ethnographic record, which we can presume reflects widespread variation in iron production in the late 19th century, the next step is to consider iron working in the archaeological record to achieve a deep time view of iron production. There is a possibility that there were significant differences in production which could be archaeologically detectable. As a result, detailed archaeological studies of iron production sites belonging to the Early and Late Iron Age were conducted to generate diachronic data to evaluate trends and patterns in prehistoric iron production. The next chapter focuses on the archaeological work done to understand iron working at Swart Village and Baranda located in northern Zimbabwe.

Chapter Five: The Archaeological Record: Swart Village and Baranda, northern Zimbabwe

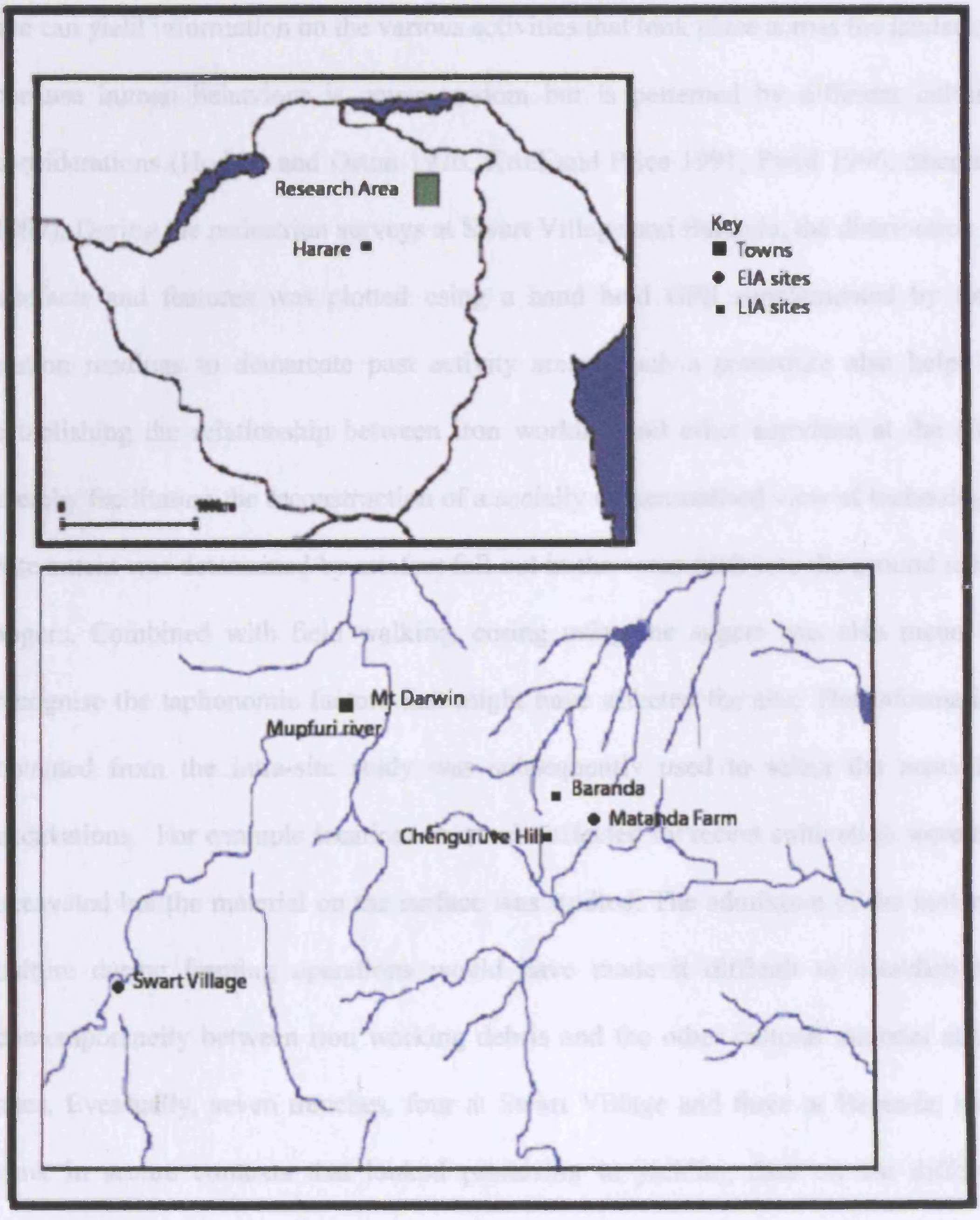
Introduction

The preceding chapter illuminated some points of divergence in practices of iron working amongst related societies at the end of the 19th and beginning of the 20th centuries. With this variation in iron production within such a limited time span, one can therefore predict the potential for significant disparities throughout Zimbabwe's iron production history and to consider that, we need to turn to archaeology. The archaeological record offers a long time frame on which to explore the patterns of prehistoric iron production in the Iron Age of Zimbabwe during which we presume technological developments took place.

A necessary preliminary was to carry out extensive consultations with the National Archaeological Sites Database (NASD) in the Museum of Human Sciences in Harare. The NASD holds files of all recorded archaeological sites in the country and unpublished field notes and site reports. The database also contains site recording forms with details on site name, site location, archaeological finds, cultural tradition, photographs and the person who discovered/recorded the site. A critical perusal of the data obtained from the archival study indicates some possible historical changes in indigenous iron production over the last 1 500 years or so. The period before AD 700 is characterised by the dearth of reported iron working debris such as slag and broken tuyeres (Robinson 1961c, Pwiti 1996). Such material fingerprints of the early bloomery process become more widespread and abundant from the close of the first millennium AD onwards. This is unlikely to be a question of differential preservation because as products of pyrotechnology, slags of all periods have got an extraordinary survival rate. Probably, this is a question of scale since some small iron objects were certainly produced. In diachronic terms, this lack of material for earlier periods was considered unimportant to this study because the available material still afforded the rare opportunity to establish local and regional metallurgical traditions from the terminal EIA to the LIA. Above all, such a study is meant to show the potential of studying the local histories of technology by considering iron working in the two different cultural epochs, rather than providing a complete picture.

A checklist was designed to select the sites to sample by detailed excavations and controlled surveys to retrieve ferro-metallurgical remains for further archaeological and laboratory studies. The checklist consisted of among other things: information on the excavation potential of the sites, surface finds, density of material and their accessibility. On the basis of the information gleaned during this exercise, several archaeological sites belonging to the Early and Late Iron Age were selected in northern Zimbabwe. A preliminary field reconnaissance was made to several sites in the region leading to the selection of Swart Village (EIA) and Baranda (LIA) in northern Zimbabwe. In addition to covering large areas, the sites are close to each other with a distance of less than twenty kilometres separating them, suggesting that geological and environmental differences were less likely to be significant. Detailed fieldwork involving intra-site studies and stratigraphic excavations were then conducted at both sites in 2004.

Figure 12 **Map of Zimbabwe showing the research area and selected sites**



Data collection: Intra-site studies

In preparation to choose the areas for excavations at the individual sites, intra-site studies were conducted at Swart Village and Baranda. As a pre-excavation strategy, intra-site studies provide information with which to define the most productive areas for stratigraphic excavations (Banning 2002, Roskams 2001). An intra-site study of a site can yield information on the various activities that took place across the landscape because human behaviour is never random but is patterned by different cultural considerations (Hodder and Orton 1976, Kroll and Price 1991, Pwiti 1996, Shennan 1997). During the pedestrian surveys at Swart Village and Baranda, the distribution of artefacts and features was plotted using a hand held GPS supplemented by total station readings to demarcate past activity areas. Such a procedure also helps in establishing the relationship between iron working and other activities at the sites thereby facilitating the reconstruction of a socially contextualised view of technology. Site extent was determined by artefact fall out in the cores sunk into the ground using augers. Combined with field walking, coring using the augers was also meant to recognise the taphonomic factors that might have affected the site. The information obtained from the intra-site study was subsequently used to select the areas for excavations. For example locations that were affected by recent cultivation were not excavated but the material on the surface was studied. The admixture of the material culture during farming operations would have made it difficult to establish the contemporaneity between iron working debris and the other cultural material at the sites. Eventually, seven trenches, four at Swart Village and three at Baranda, were sunk in secure contexts that looked promising in yielding data on the different activities in the iron working cycle.

Swart Village

Extending for over one hectare on the western bank of Mupfuri River, Swart Village is a fairly well preserved Early Iron Age village site. It is approximately ten kilometres southwest of the modern town of Mt Darwin. The drainage of the area around the site is oriented eastwards towards the Mazowe-Ruya basin and the Indian Ocean. Topographically, the site is characterised by a gradual rise in altitude from the banks of the river Mupfuri, which ends at the foot of the hills due west of the site. The land between the river and the hills is very fertile and contains a lot of archaeological materials on the surface. The geology of the surroundings of Swart Village consists of Precambrian granites, schist belts, and gneisses belonging to the Shamvaian geological complex. This basement complex is very rich in mineral ores of metals such as iron and gold which would have been exploited by prehistoric peoples (Pikirayi 1993, p. 27). Swart Village and its bordering areas are richly endowed with red loamy soils whose good agricultural potential should have attracted human settlement. Basing on current vegetation patterns, Wild and Fernandes (1967, pp. 14-23) posited that the vegetation of the locale of Swart Village in the past mainly comprised of deciduous miombo savanna woodlands in which *Brachystegia* species dominated. The trees would have been used for domestic building purposes as well as in craft activities such as iron production. Grasses such as *eragrotis aspera* which are ideal for grazing animals and for thatching houses normally grow in such type of savanna forests.

In view of the rich resources abounding in the environs surrounding the site, it is plausible to assume that prehistoric occupants were attracted by abundant ore resources, agriculturally rich soils and proximity to water sources. To the early farmers, water was an important resource in the iron working operations as well as for domestic and agricultural purposes (Pikirayi 1993, p. 29, Pwiti 1996, p. 132). The iron implements obtained from the smelting and smithing processes would then be used to cultivate the fertile land. Thus commenting on the location of EIA communities in northern Zimbabwe, Pwiti (1996) noted that water was of paramount importance to early farmers in iron production and agriculture to the extent that villages were normally sited within easy reach of perennial water bodies. The area of Swart Resettlement in which the site is located is sated with iron ores such as banded ironstones which are clearly visible on the mountains adjacent to the site. Prehistoric peoples at Swart Village probably exploited such ores for their iron requirements. Hardwoods from the adjacent woodlands provided ample fuel for high temperature processes such as iron working.

Pedestrian surveys conducted at Swart Village revealed scattered remains of slag, pole impressed earthen daub *(dhaka)* and pottery observable on the surface and in the stratigraphy exposed by gully erosion in some areas. This raised questions about how iron production was organised at the site and its spatiality in the terminal EIA period. From the surface material, it is not immediately clear whether the inhabitants of Swart Village possessed knowledge of pottery making, agriculture and metallurgy simultaneously or whether the other crafts were late developments, reflecting the need for controlled excavations. The surface finds at Swart Village are rich in most parts of the site, suggesting that the place was occupied over a long period of time or that there was a large population at the site. The pottery from the surface is decorated with wavy lines, comb-stamping designs, broad line incisions and punctates. From a typological view point, this decoration style is similar to that from sites of the same period throughout southern Africa (Huffman 1970, Phillipson 1985, Soper 1982). This material closely resembles that from EIA villages such as Kadzi in the mid-Zambezi valley (Pwiti 1996), Matanda Farm (Pikirayi 1993, 2001) and Chitope (Garlake 1969), and has been linked with the arrival of the Bantu people in southern Africa (Mitchell 2001, Phillipson 1985, Soper 1982).

Interspersed with these remains of pottery are architectural remains which show evidence of houses. These are also dotted all over the site with some dense concentrations in the central and eastern parts closer to the river. The intra-site study demonstrated that architectural remains (pole impressed *dhaka*) exists in the same contexts with the pottery and slag. Visible on the surface are large concentrations of iron pyrometallurgical remains including small (less than 1 x 1 cm) to large blocks of slag (20 cm x 30 cm), tuyere fragments and possible ore remains. Mupfuri, the name of the river on whose banks the site is located means blacksmith in the Shona language (Pikirayi 1993, p. 86). This may mean that the area's reputation for its iron working exploits may date to the EIA. However, the probability that the name survived from the EIA is low.

Excavations

The interpretation of the results of the localised field walking and the distribution of artefacts led to the selection of areas for excavation. About twenty five percent of the site was disturbed by small-scale cultivation activities. In this cultivation zone, ferro-metallurgical remains, pottery, bone and collapsed pole impressed earthen structures are the most frequently encountered finds. The eastern side of the fields had been recently ploughed and scores of archaeological finds were exposed. These were akin to those found on the surface elsewhere at the site. Consequently, shovel test pits were dug to establish the nature of the archaeological finds below the plough zone which turned out to be the same as those visible in the ploughed area. Some samples of iron working remains were collected in order to compare them with those from the excavated areas. In view of the need to excavate areas with a clear stratigraphy, these ploughed areas were not considered for excavations. The trenches were sited on the eastern and western parts of the site where the disturbance in recent years appeared minimal. Trenches 1 and 2 were located on the eastern edges, between c. 50 and 80 metres from Mupfuri River. The area had large concentrations of iron working remains in the form of possible collapsed furnace remains, broken tuyeres, slag and tuyere plugs. Two 1. 5 by 1. 5m trenches were excavated to a depth of less than one metre. The two trenches produced large blocks (approximately 20 cm by 30 cm) of iron slag that had grooved depressions/deformations, potsherds, large pieces of broken tuyeres (c. 10 cm length) and remains of ore.

Two additional trenches were then sunk on the western edge of the site adjacent to the area where augur cores had revealed the existence of cultural material close to the river. Trench 3 measuring 2 by 1 metres was sited adjacent to smooth rock outcrops surrounded by slag which could have resulted from the smithing process. Trench 4 with similar dimensions to Trench 3 was located on a surface concentration of pottery with wavy lines and comb-stamped motifs. These trenches yielded about half the amount of iron working material recovered from the first two trenches. Iron extraction remains, charcoal samples and potsherds were collected for further analyses in the laboratory. The description of the stratigraphy and finds from the trenches follows below.

Figure 13 **Map of Swart Village showing the first excavations**

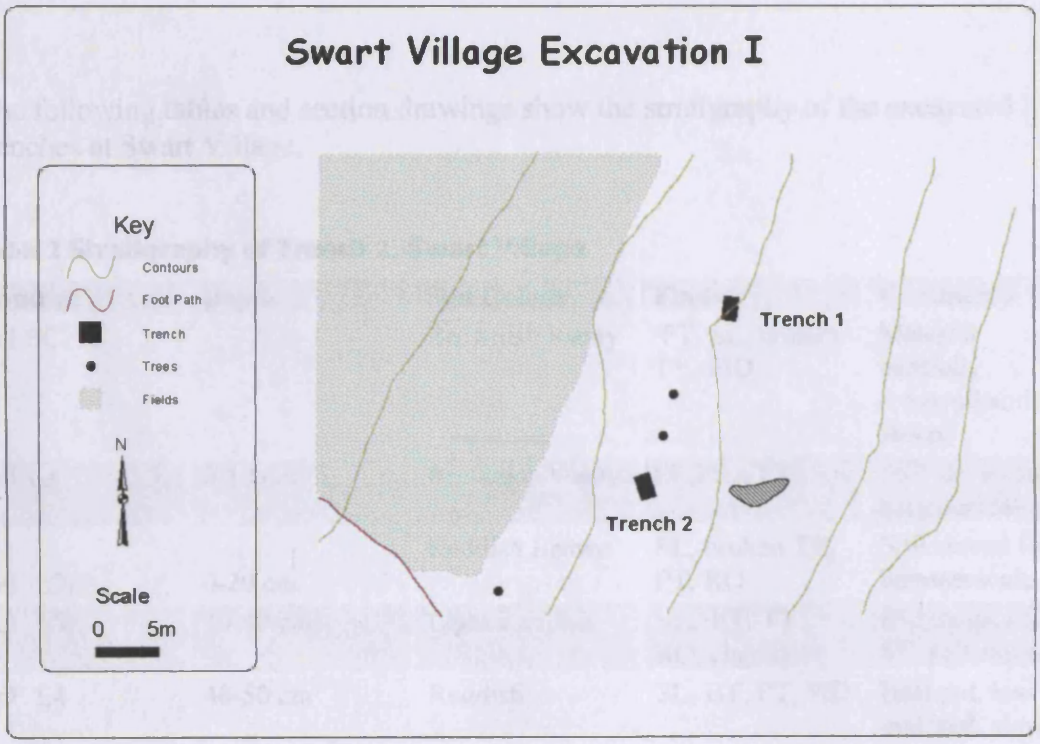
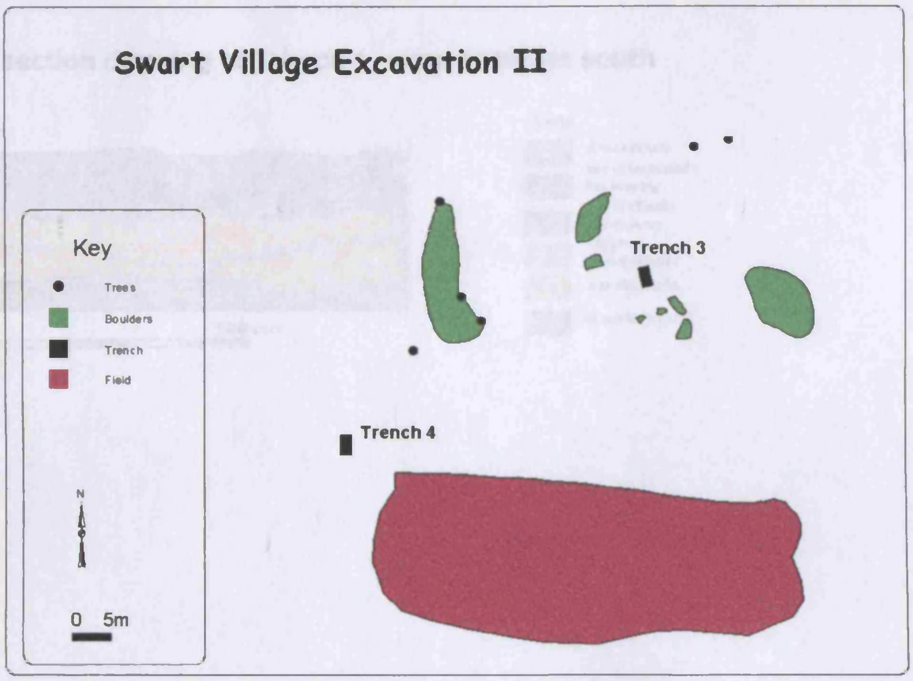


Figure 14 **Map of Swart Village showing the second excavation**



The following tables and section drawings show the stratigraphy of the excavated trenches at Swart Village.

Table 2 **Stratigraphy of Trench 1, Swart Village**

Context	Depth	Soil Colour	Finds	Comments
Trl SC		Brownish loamy	PT, SL, broken TY, PID	Material carefully removed and sieved
Trl L1	0-10 cm	Brownish loamy	SL,PID, PT	Soil sieved for hammerscale
Trl L2	0-20 cm	Reddish Brown	SL, broken TY, PT, RO	Soil sieved for hammerscale
Trl L3	30-40 cm	Light Reddish	SL, PT, TY, RO, charcoal	Big lumps of SL, soil sieved
Trl L4	40-50 cm	Reddish	SL, BT, PT, PID	Half pot, less material, sieved
Trl L5	Below 50 cm	Dark red		Sterile soil

Key: TR=Trench, L1=Layer 1, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, PT= Pottery

Figure 15 **section drawing of Trench 1, view from the south**

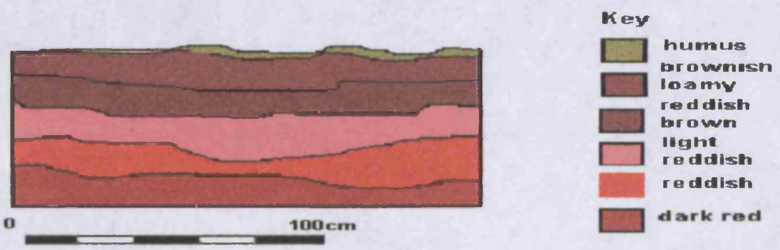


Table 3 **Stratigraphy of Trench 2, Swart Village**

Context	Depth	Soil Colour	Finds	Comments
Tr2 SC		Grey	Small fragments of PT	Top soil mixed with humus, sieved
Tr2 L1	0-10 cm	Light grey	PT, PID, SL	Very little slag, sieved
Tr2 L2	0-20 cm	grey	PT, SL, PID, Bone	Soil sieved
Tr2 L3	30-40 cm	Greyish brown	PT, SL, Charcoal	Lavishly decorated pottery, sieved
Tr2 L4	40-80 cm	Reddish grey	PT, SL, TY, RO	Largest concentration of material
Tr2 L5	Below 80 cm	Natural gravel		No material

Key: L1=Layer 1, TR=Trench, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, PT= Pottery

Figure 16 **section drawing of Trench 2, view from the east**

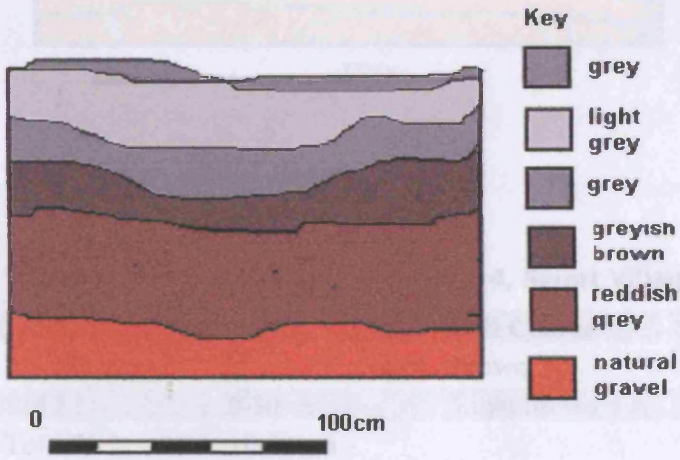


Table 4 **shows stratigraphy of Trench 3, Swart Village**

Context	Depth	Soil Colour	Finds	Comments
Tr3 SC		brown	TY, SL,	sieved
Tr3 L1	0-10 cm	Light brown	PT, SL, BT	sieved
Tr3 L2	10-20 cm	Reddish brown	SL, PT, BT, PID	sieved
Tr3 L3	20-30 cm	Reddish, rocky	SL,	sieved
Tr3 L4	Below 30 cm	Natural gravel		

Key: L1=Layer 1, TR=Trench, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, PT= Pottery

Figure 17 **section drawing of Trench 3, view from the south**

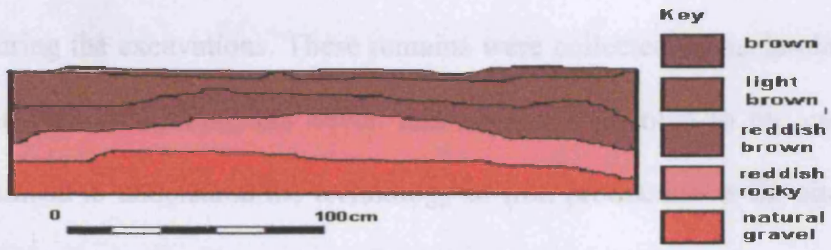
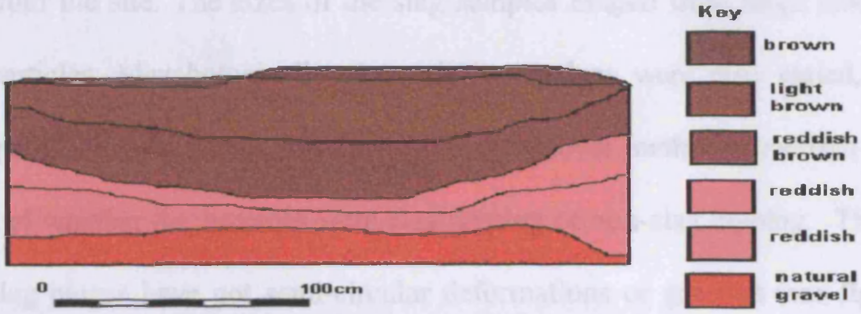


Table 5 **shows stratigraphy of Trench 4, Swart Village**

Context	Depth	Soil Colour	Finds	Comments
Tr4 SC		brown	PT, PID	sieved
Tr4 L1	0-10 cm	Light brown	PT, PID,	sieved
Tr4 L2	10-30 cm			
Tr4 L3	30-40 cm	reddish	PT, PID	sieved
Tr4 L4	40-50 cm	reddish	BT, SL, PT, PID	
Tr4 L5	Below 50 cm	Natural gravel		

Key: L1=Layer 1, TR=Trench, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, PT= Pottery

Figure 18 section drawing of Trench 4, Swart Village



The Finds: Iron working remains

The tuyeres, slag and furnace remains recovered from all the trenches weighed c. eighty kilograms. Different types of slag, tuyere plugs, broken tuyeres, hammerstones and possible ores indicating various stages in the production cycle were unearthed during the excavations. These remains were collected for technological studies in the laboratory and Chapters Seven and Eight are devoted to the analytical procedures utilised to understand the technology of iron production at the site. In order to make meaningful comparisons regarding the quantities of ***slag*** from the four trenches, the mass of slag per cubic metre of excavated deposit was calculated for each trench. The volume excavated in Trenches 1 and 2 was 3m³ which produced 40 kg slag; a density of around 15kg/m³. For Trenches 3 and 4, the volume excavated was around 1, 6m³, yielding 20 kgs of slag, and a density of around 12kg /m³. All the trenches thus yielded almost identical slag volume per deposit. This tentatively indicates that iron was worked at a similar rate across the whole site though of course one has to consider factors such as potential shifting production bases which would lead to almost identical accumulations of slag on the site over time.

As shown in Table 2, the bulk of the material in the trenches was sandwiched between layers 2 and 4 which also contain some of the most lavishly decorated EIA pottery from the site. The sizes of the slag samples ranged from large blocks to very small particles. Morphologically, these different slags were also varied, evoking several questions regarding issues such as slag removal methods practised at Swart Village and whether the furnaces were slag tapping or non-slag tapping. The majority of the slag pieces have got semi-circular deformations or grooves (**see fig 19**) which may have developed during solidification of the slag. Some of these grooves have bark impressions suggesting the potential use of wooden poles in extracting slag from the furnaces. The slag was very dense and black in colour and most of it was fully fluid, showing that high temperatures were attained in the furnaces. Some rusty and highly magnetic slag was found in Trench 2 in association with a hammerstone which could possibly have been used in the smithing process. However, such observations must be corroborated with detailed metallurgical studies of the remains in the laboratory. Some of the smaller slag pieces were ropy and had occluded soil at the base showing that they had flowed out of the furnace in a liquid state. Very few fragmentary pieces of possible furnace wall were also recovered in Trench 4. It was hoped that further analyses of the material would throw light on the types of clays used by smelters and smiths at Swart Village. One of the commonest categories of iron working remains recovered at Swart Village are large tuyeres which were vitrified at the ends that had contact with the reactions in the furnaces. The average internal and external diameters of the tuyeres were 50 mm and 70 mm respectively. Although no furnace bases were recovered, these tuyeres indicate that the furnaces were probably large though it is difficult to estimate their actual sizes. Several samples of tuyere plugs were recovered (slag which solidified in the tuyere and thus assumed its cylindrical shape) further confirmed the large diameters of the tuyeres and that the slag was at one time fully liquid. During the process of sieving the soil from the individual layers from all the trenches, a magnet was run through the soil and magnetic pieces were collected for further studies in the laboratory. The information potential of the magnetic pieces was shown by the fact that the magnetism of the soil was different which could help in identifying hammerscale and possible smithing areas at the site.

Figure 19 **Iron working remains from Swart Village**

a). Tap/flow slag. Trench 1, Layer 3

b). Tuyere fragment, Trench 2 layer 3

c). Possible hammerstone, Trench 1, Layer 2

d). Internal diameter of tuyere, Trench 2, Layer 3

e) Lump of slag with semi-circular depressions Trench 1, Layer 4

f). Piece of slag with impressions Trench 4 Layer 3

Other finds

Stratified in the same contexts with the iron working remains were pottery fragments, pole impressed *dhaka* and animal bone showing the contemporaneous nature of the different cultural activities at the site such as pottery making and iron working. The recovery of large quantities of lavishly decorated and diagnostic pottery from all the trenches presented an opportunity to conduct typological analyses of the pottery which facilitated the placement of Swart Village within the culture historical framework of northern Zimbabwe established by Pwiti (1996). In the lower levels of the four trenches, EIA pottery and very few slag pieces and broken tuyeres dominate the assemblage. The concentration of slag and pottery increases in the middle to upper layers where blocks of slag become progressively bigger to about 20 x 30 centimetres. Tentatively, this suggests that after initial settlement at the site, iron production and pottery making may have increased in scale reaching high levels before the site was abandoned. The interpretation of the distribution of artefacts thus suggests that iron may have been worked throughout the whole site. Though settlement may have started in one area, by the time the site was abandoned the distribution of material shows that the site was possibly occupied in its entirety. The association of iron smelting residues such as tuyere plugs with domestic debris such as pottery and bone indicates that iron may have been smelted within the settlement at Swart Village. The identifiable bone specimens showed that the assemblage was dominated by medium sized bovids. Only, three parts of left humeri can be positively identified as cattle. The small amount of the faunal remains makes it difficult to establish the ratio between domesticated and wild animals at the site.

The typological description and analysis of pottery from Swart Village

The typological approach utilised in this study followed the analytical methodology developed by Pikirayi (1987, 1993), Pwiti (1996) and Chirikure *et al.* (2001) for analysing Iron Age ceramics in northern Zimbabwe. The use of a similar analytical framework also made it easy to compare the Swart Village assemblage with those from related sites in the region. This facilitated the definition of the place of Swart Village in the culture historical sequence of northern Zimbabwe. The methodology combined attributes of decoration technique, decoration placement and vessel forms. This is because shape form and decoration techniques can reflect relationships between different sites and their influence on each other (Chirikure *et al.* 2001, Huffman 1989, Pikirayi 1993). Initially, a data capture sheet was designed to record the most salient features of the pottery. Traits of each sherd were listed and attribute states were derived from them and registered on the database for classification. In the classification, traits of vessel shape, lip form, rim diameter, surface treatment, decoration technique, placement and motifs were utilised. These attributes offer a useful avenue for comparing closely related ceramics and they are also the most effective in both inter-site and intra-site comparison of the pottery (Chirikure *et al.* 2001, Huffman 1989, Sinclair *et al.* 1993). Traits were examined individually and in combination with others to define the range of motifs and vessel shapes represented by the assemblage.

Only diagnostic sherds that displayed important characteristics such as decoration and vessel contour were used. Diagnostic sherds were defined as those which could be unequivocally assigned to vessel parts of rim, neck, shoulder, and body together with decorated parts from any part of the vessel. Undiagnostic sherds comprised plain sherds that could not be assigned to any vessel part with certainty. Undecorated sherds less than 2 cm^2 were considered as undiagnostic and were not included in the analyses. A total of 967 sherds were recovered from all the trenches of which 198 were classified as diagnostic. The individual sherd summaries entered on the summary sheet were used as the database for classifying the pottery. The different vessel parts allow the ordering of fragmented potsherds into vessel shape groups. The isolation of vessel parts was seen as crucial in defining shape profiles on the basis of vessel contour (Pikirayi 1993, p.121, Pwiti 1996, p. 101). Sherds were broadly identified as pots (restricted vessels with simple contour) or bowls (unrestricted vessels with maximum diameter larger than vessel height) (Chirikure *et al.* 2001). Although categories such as pots or bowls are functional, they are also form related making it easy to identify and quantify the range of shapes represented in an assemblage (Pwiti 1996, p.132). Using this procedure, vessel shapes were established for the Swart Village assemblage (**see Fig 20**). These are as follows:

Bowls

1. Open hemispherical bowls with bevelled, tapered or square lips (some of these had decorations in the inside or on the lips.

2. Constricted bowls with simple lip forms

Pots

3. Shouldered pots with insloping rims
4. constricted pots with simple rounded lips
5. Indeterminate – this is a miscellaneous class that could not be assigned to any shape profile with certainty

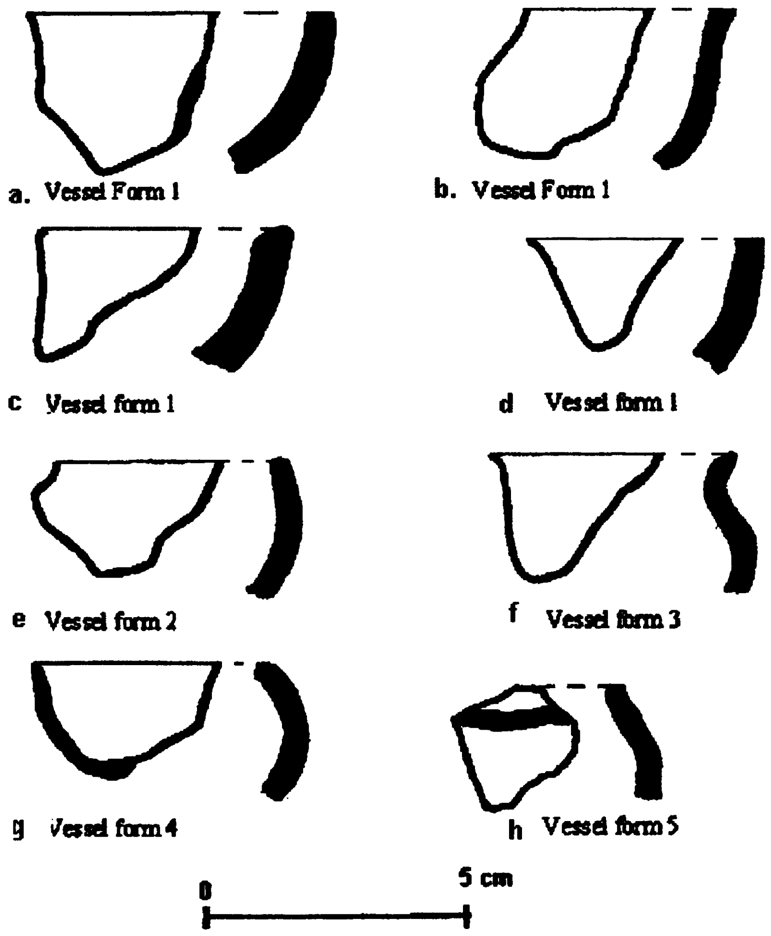
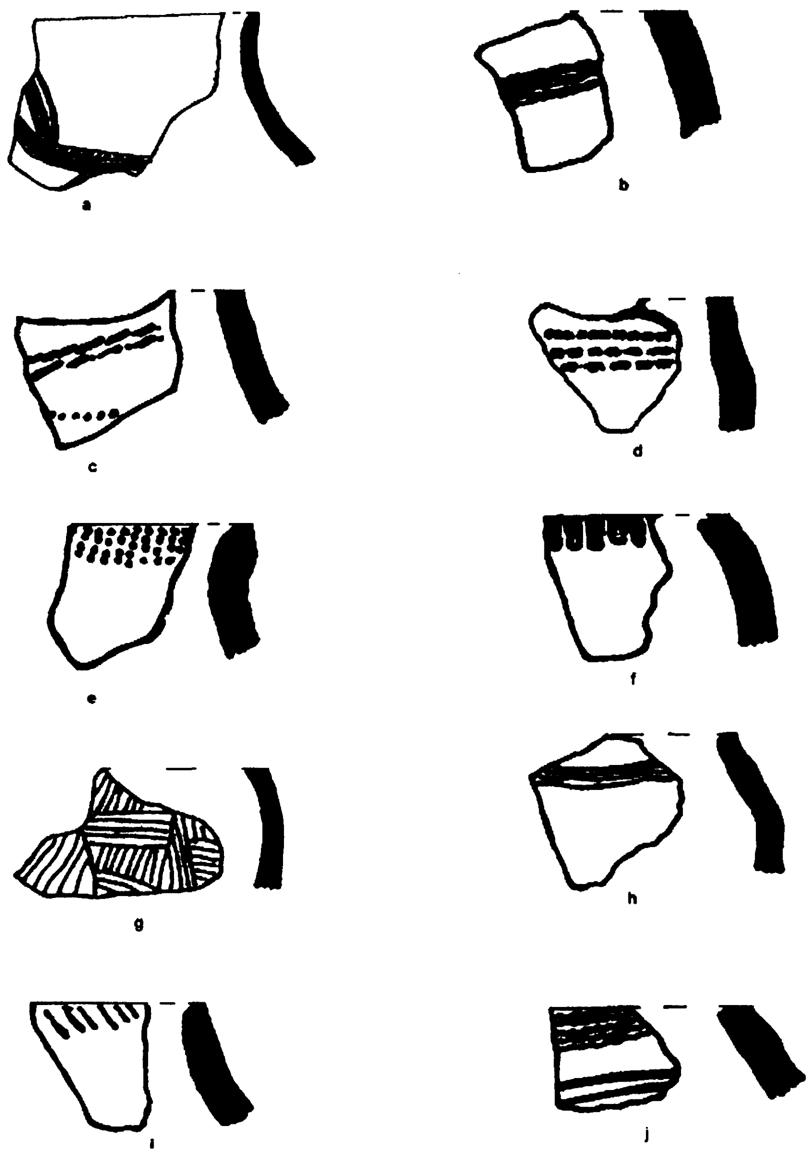


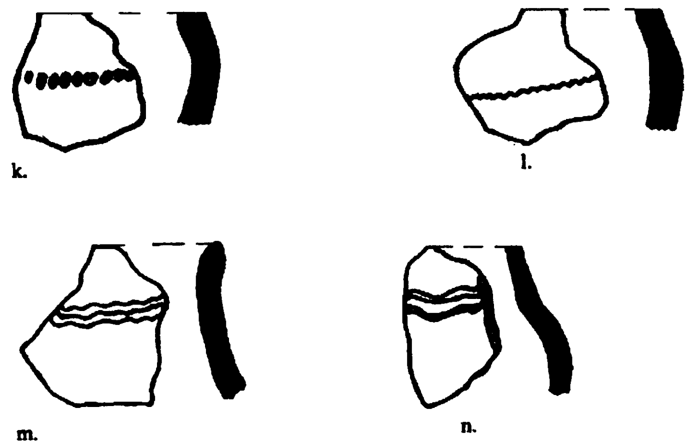
Figure 20 Vessel Forms, Swart Village

The analysed pottery was generally well polished. Most of the vessels were well fired with a brown to blackish brown colour. Several decoration techniques appear on the

Swart Village assemblages **(Fig 21)**. These include comb-stamping, incisions (fine line or broad lines), wavy lines, punctates, cross-hatching and stab and drag. While comb-stamping appears to be the most dominant decoration form on all classes of vessels, wavy lines and stab and drag only appear on shouldered pots.

Figure 21 Decorated pottery from Swart Village





a-c = stab and drag, d-f = combstamping, g-j = incisions, h = punctation, l-n = wavy lines

Swart Village within the wider context

In every essential, the pottery from Swart Village broadly compares with that documented at contemporary sites such as Baranda (lower levels), Madzinga Farm and Matanda Farm situated in the Chesa communal areas of Mt Darwin. The range of vessels and decoration motifs represented at this Chesa cluster of sites such as pots with insloping rims and wavy lines indicates that they are part of the same cultural tradition (**see Fig 22**). Pikirayi (1993) dated the assemblages from around AD 800 to around the 13th century AD which is quite consistent with the ^{14}C date obtained for the Swart Village material (Analysis No. Gra 24906, AD 800). Of the Chesa group of sites, Matanda is quite interesting from a metallurgical viewpoint because like Swart Village, it contains evidence of iron working in similar contexts with pottery and architectural remains. However, the iron working remains at Matanda indicate that the scale of production was comparatively lower than at Swart Village.

Figure 22 **Decorated pottery from Madzinga Farm (after Pikirayi 1993)**

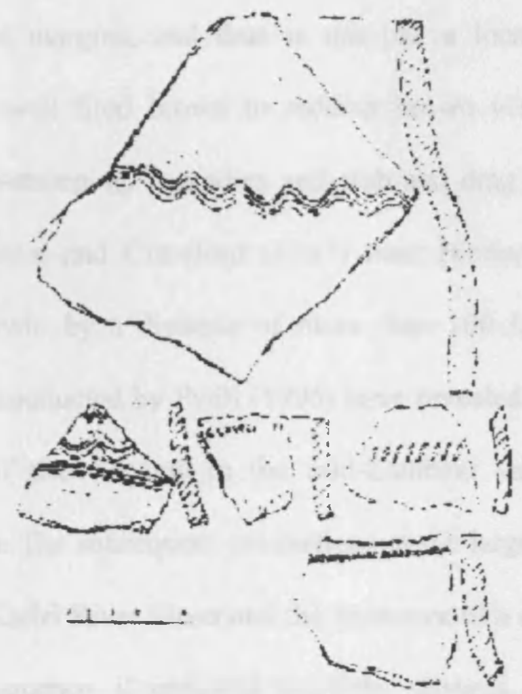


Figure 23 **Decorated pottery from Kadzi, after Pwiti (1996)**

More importantly, the pottery from these sites has a wider distribution in northern Zimbabwe and adjacent margins, and thus is not just a local phenomenon. The generally thick bodied well fired brown to reddish brown vessels decorated with motifs formed by comb-stamping, meanders and stab and drag have been found by Garlake (1969) in Guruve and Crawford (1967) near Bindura. These places are separated from Mt Darwin by a distance of more than 100 kilometres. Extensive archaeological surveys conducted by Pwiti (1996) have revealed the existence of this pottery at a number of sites located in the mid-Zambezi valley such as Kadzi, Kamukombe and Chigu. The subsequent excavations at the large open village site of Kadzi on the banks of Kadzi River illustrated the existence of a multi-component site whose occupational sequence illuminated possible changes in ceramics at the interface between the first and second millennia AD. As Pwiti (1996) has posited, the elaborately decorated and thickened vessels typical of the mid first millennium AD Iron Age communities seem to be replaced by less ornate thinner vessels dated to the mid second millennium AD. Decoration techniques such as wavy lines and stag and drag patterns are also frequent at Kadzi and Kamukombe just as has been observed for Swart Village and the lower levels at Baranda and Madzinga Farm.

The pottery excavated at Kadzi, Swart Village, Chitope and Madzinga Farm certainly has a much wider distribution which is between Mt Darwin, the mid-Zambezi valley and Bindura. Because of the apparent typological differences between this terminal EIA pottery and other ceramic traditions dating to the same period such as Coronation, Pwiti has proposed the name Kadzi for this distinct sub-group or regional cluster of pottery. This Kadzi tradition has stylistic resemblances with that from southern and eastern Zambia such as Dambwa, Kamangoza and Kumadzulo in which wavy lines and stab and drag designs dominate. The Kadzi pottery can be viewed as the northern variant of the larger Gokomere/Ziwa Tradition (EIA) which fits into the context of other regional ceramic traditions in the whole of Zimbabwe (Huffman 1971, Pikirayi 1993, Pwiti 1996). Iron was worked with varying degrees of intensity at these Kadzi tradition sites indicating that iron working was an essential feature of the technology of early farmers. These sites were also connected to the trade and exchange networks on the Indian Ocean seaboard. The recovery of white and translucent glass beads from the upper levels at Kadzi is testimony to this assertion. In the absence of extensive excavations, the existence of such trading relations at Swart Village and Madzinga Farm can only be conjectural. However, the intensive iron working at Swart Village can be viewed within the context of the emergence of the accumulation of wealth and the emergence of intra and inter-regional trade which precipitated the emergence of complex societies. In this connection, individuals who possessed knowledge of iron working may have strategically positioned themselves to become dominant in society.

Baranda

Baranda is a very extensive open Zimbabwe tradition site situated at the border of Farms 3, 4, and 7, Chesa in Mt Darwin. The site is located on a flat plain with some partially exposed rock outcrops on three parts of the site: the western, central and southern parts bordering Chenguruve hill. Previously investigated by Pikirayi (1993) the site covers an area of 2 km^2. However, this study was restricted to the core of the settlement in the north-western part of the site. The soils on the site are darkish grey sandy loam, a reflection of the underlying geology mainly consisting of granite rocks (Pikirayi 1993, Sinclair *et al.* 1993, Thomson 1965, Vincent and Thomas 1961).

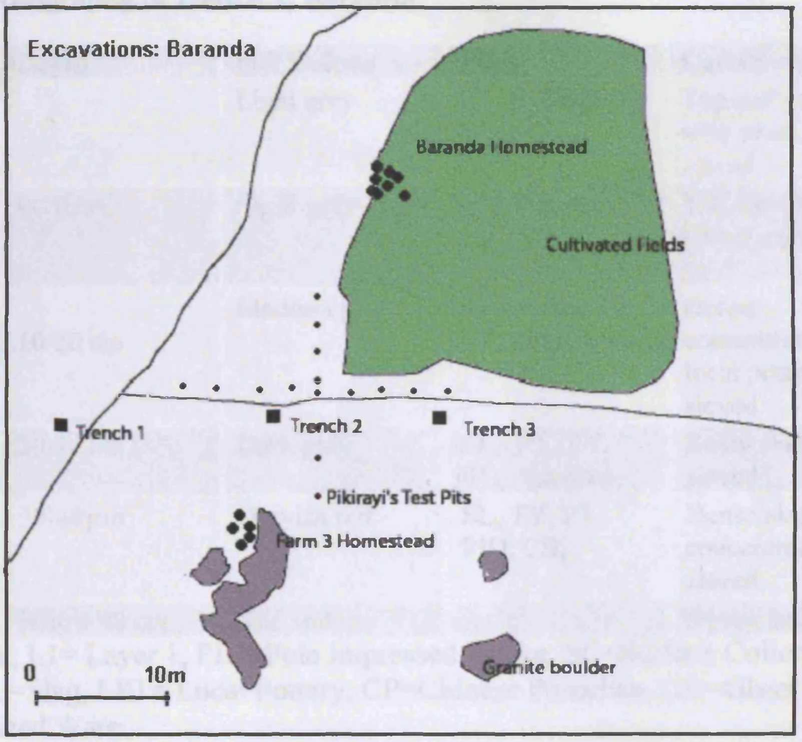
During the Late Iron Age period to which Baranda belongs, crops such as sorghum and millet would have been cultivated on these soils (Abraham 1959, Beach 1980, Sinclair *et al.* 1993). The site has been disturbed by constant human use over long periods of time including small scale farming operations from the 1960s to the present. However, there are some parts of the site where the disturbance in the recent years has been minimal.

The vegetation in the environs surrounding the site originally consisted of deciduous savannah woodlands as indicated by the secondary vegetation on Baranda Farm and adjacent terrains. In recent years acacia species have become the dominating tree species on most parts of the site. The site is located close to the Mukaradzi River valley which is famed for its alluvial gold deposits and iron rich stones (Abraham 1959, Pikirayi 1993, Sinclair *et al.* 1993). There is "a very close geochemical association between gold and iron in Zimbabwean iron ore deposits which suggests a connection between ferrous and auriferous workers in the LIA" (Prendergast 1974, p. 254). Baranda was strategically located to exploit the cultivable soils, iron ores and the gold that was extracted in the nearby river valleys and mountains. From the 16th century onwards, Portuguese documents talk of thriving Afro-Portuguese trading relations at the site in which locals exchanged not only gold and iron (Abraham 1959) but also agricultural produce in exchange for exotic goods such as glass beads and imported ceramics. A series of thermoluminescence dates from samples collected by Pikirayi (1993, p. 82) dated the site from the late 15th to the 18th centuries thus concurring with the dating from the Mutapa historical documents which identify Baranda as the trading centre of Massapa. The bulk of the archaeological finds observable on the surface at Baranda consist of charcoal mounds, iron extraction remains, graphite burnished pottery of the Zimbabwe tradition, imported ceramics and glass beads. Archaeological features at the site include house floors which are discernible on the western parts of the site in association with iron working activities. With the aid of radiometric methods of dating such as thermoluminescence and meticulous stratigraphic excavations, Pikirayi (1993, p. 154) proposed that the iron working remains at the site were contemporary with other artefact suites like local pottery. In order to understand the dynamics of iron working in the Late Iron Age, Baranda was selected for systematic archaeological investigations because it is a Zimbabwe tradition site with evidence of iron pyrometallurgical remains in association with house foundations and other domestic debris.

Excavations

The results of the pedestrian surveys showed that the concentrations of different artefact categories were clustered in three different parts of the site. Glass beads and local graphited pottery were concentrated in the north-eastern parts of the site. Imported wares such as Chinese blue and white porcelain, stone ware, and Portuguese glass were heavily concentrated in the eastern and southern parts of the site while in the western and northern parts of the sites metal processing remains dominate the material on the surface. However, the occurrence of different archaeological remains is not mutually exclusive as one could find each class of material culture all over the site albeit in different proportions. In addition, charcoal mounds occur in some parts of the site and these may be linked to high temperature processes such as iron working. This information was augmented by data from Pikirayi (1993)'s work on the site. Pikirayi plotted the distribution of imported artefacts and dug a trench in the eastern part of the site where he recovered large quantities of glass beads and other imports. In his test pitting, he found a lot of iron working remains in the western parts of the site. Our results therefore reflected the same spatial configuration of archaeological finds at Baranda. Since the material from the southern and eastern parts of the site was studied in detail by Pikirayi (1993), attention was concentrated on the western and northern parts of the site. Trench 1 (1 x 2m) was excavated on the north-western part of the site across the road. This area was selected because a cleaned section on the road side showed that the area had some probable house foundations, bone, local pottery, glass and iron slag in the middle strata. Due to a dense vegetation cover, Trench 2 (1 x 2m) was randomly sited in the south-eastern area, while Trench 3 (1 x 2m) was located in the middle of the western part where there were imported wares, beads and local pottery on the surface. The majority of the finds from the trenches mirrored those on the surface and these included remains of ore, broken tuyeres, and slag, all mixed with local pottery, beads and some imported wares. Finally, as at Swart Village, the relationships between all the trenches were established for eventual plotting on the site map. The descriptions of the stratigraphy and the finds follow below.

Figure 24 **Map of Baranda showing the excavated areas**



The following tables and figures show the stratigraphy and sections of the trenches excavated at Baranda.

Table 6 **shows stratigraphy of Trench 1, Baranda**

Context	Depth	Soil Colour	Finds	Comments
TR1 SC		Light grey	PT, B, CB, PID	Top soil mixed with grass, sieved
TR1 L1	0-10 cm	Light grey	B, PT, bone, CB, SL	Soil sieved for hammerscale
TR1 L2	10-20 cm	Medium grey	SL, broken TY, PT, furnace wall	Dense concentration of local pottery, sieved
TR1 L3	20-30 cm	Dark grey	SL, PT, TY, RO, charcoal	Rusty slag, soil sieved
TR1 L4	30-40 cm	Greyish red	SL, TY, PT, PID, CB,	Dense slag concentration, sieved
TR1 L5	Below 40 cm	Red soil		Sterile soil

Key: TR=Trench, L1= Layer 1, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, LPT= Local Pottery, CP=Chinese Porcelain, GB=Glass Beads, GW=Glazed Ware

Figure 25 **section drawing of Trench 1, Baranda, view from the west**

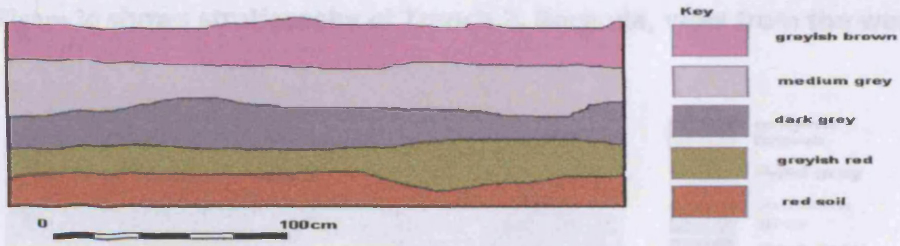


Table 7 **shows stratigraphy of Trench 2, Baranda**

Context	Depth	Soil Colour	Finds	Comments
TR2 SC		Greyish brown	CB, Small fragments of PT	Fragments of a floor, sieved
TR2 L1	0-10 cm	Light grey	PT, PID, SL	Very little slag, sieved
TP2 L2	10-20 cm	Medium Grey	PT, Beads, PID, Bone	Soil sieved
TR2 L3	20-30 cm	Dark Grey	PT, SL, Beads, House Floor, TY	Graphited pottery dominated, sieved
TR2 L4	Below 30 cm	Reddish grey		Sterile soil

Key: L1=Layer 1, TR=Trench, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, LPT= Local Pottery, CP=Chinese Porcelain, GB=Glass Beads, GW=Glazed Ware

Figure 26 **shows stratigraphy of Trench 2, Baranda, view from the west**

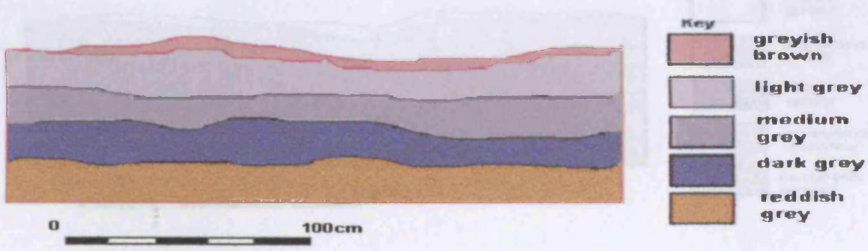
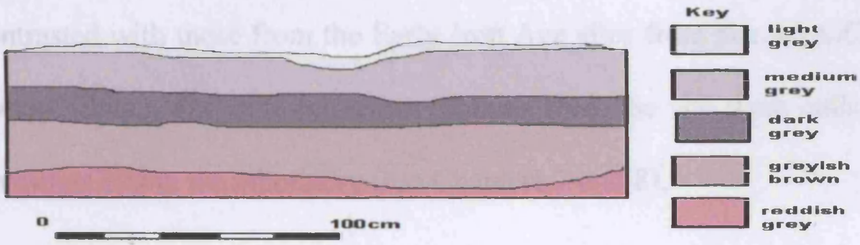


Table 8 **shows stratigraphy of Trench 3, Baranda**

Context	Depth	Soil Colour	Finds	Comments
TR2 SC		Grey	CP, Small fragments of PT	Fragments of a floor, sieved
TR2 L1	0-10 cm	Light grey	PT, PID, SL	Very little slag, sieved
TP2 L2	10-20 cm	grey	PT, Beads, PID, Bone	Soil sieved
TR2 L3	20-40 cm	Greyish brown	PT, SL, Beads, House Floor, TY	Graphited pottery dominated, sieved
TR2 L4	Below 40 cm	Reddish grey		Sterile soil

Key: L1=Layer 1, TR=Trench, PID=Pole Impressed Dhaka, SC=Surface Collections, TY=Tuyeres, SL=Slag, LPT= Local Pottery, CP=Chinese Porcelain, GB=Glass Beads, GW=Glazed Ware

Figure 27 **shows section drawing of Trench 3, Baranda, view from the east**



The Finds: Iron working remains

A wide range of metallurgical finds although in varying densities, were recovered during the excavations at the site. These consisted of slag, broken tuyeres, possible ore, three bangles of copper wire and possible crucible fragments. Iron working remains recovered had a total weight of about 25 kgs, significantly less than that from Swart Village. For meaningful comparisons with Swart Village to be made, the kg/m^3

was calculated at Baranda. The total volume excavated deposits for the three trenches was 3.4m^3 which produced a total of 25 kgs of slag and an average of 7. 35 kgs per m^3. At Baranda, Trenches 1 and 3 yielded the majority of the finds with different kinds of slag, broken tuyeres and possible remains of ore. Some of the slag from the site had a dense structure indicating that it was once fully fluid. Noteworthy but yet unexplained is the marked difference in the size of slag pieces recovered at the site from those from Swart Village. Compared to the large pieces with grooved deformations typical of the Swart Village material, the largest pieces at Baranda averaged 5 cm x 3 cm. Some slag pieces were very rusty and highly magnetic possibly with sizeable inclusions of metallic iron. The discovery of some ore fragments from Trenches 1 and 3 demonstrates the likelihood of smelting at the site corroborated by the retrieval of tuyere plugs in Trench 3. Most of the tuyere fragments were highly fragmented but a few intact pieces showed that they had a mean internal diameter of 25 mm and an external one of 35 mm. This small size of the tuyeres suggests that the furnaces used at Baranda were very small and thin walled when contrasted with those from the Early Iron Age sites from northern Zimbabwe such as Swart Village. The iron extraction remains from the site were collected for detailed investigations in the laboratory (see Chapters 7 and 8).

Figure 28 **Iron working remains from Baranda**

a) Furnace slag Trench 1 Layer 4

b) Ore remains, Trench 3 Layer 3

c) Tuyere fragment, Trench 3, Layer 2

d) Tuyere fragment, Trench 1 Layer 2

d) Tuyere fragment, Trench 1 Layer 3

e) Tuyere fragment, Trench 3 Layer 1

Other Finds

In addition to the metal working debris, the excavations at Baranda yielded local graphited pottery, parts of house floors, Indian red and blue beads, animal bone and fragments of Chinese blue on white porcelain. The local pottery from the three trenches weighed close to 7 kgs. The pottery was characterised by very thin bodies and the absence of the elaborate decorations typical of the preceding Early Iron Age pottery. Trench 2 which produced the remains of a house floor had the largest quantities of glass beads with the Indian red, dark and light blue having the highest frequency. Pikirayi (1993) has posited that there are some parallels between the beads from Baranda with those from other Afro-Portuguese sites such as Dambarare and Luanze. A small quantity of animal bone was recovered from all trenches. The identifiable bone fragments consisted of distal humeri and phalanges of medium to large bovids at the sites. As a Zimbabwe tradition site, cattle would most likely have been a part of the animal economy at the site representing the wealth of its inhabitants (Sinclair *et al.* 1993). The co-existence of local pottery, iron processing and a large quantity of imported artefacts such as Chinese blue on white porcelain is indicative of a thriving trading relationship between the inhabitants of Baranda and the Indian Ocean seaboard.

The typological description and analysis of pottery from Baranda

Local pottery from Baranda was analysed in order to place it within the broad culture historical sequence of northern Zimbabwe. For comparative purposes, the pottery was analysed using the same analytical framework utilised for the Swart Village material. Methodologically, this also made it easier to compare the results with those obtained by Pikirayi (1993) for the same site. However, the majority of the pottery from Baranda was highly fragmented. This made it difficult to isolate the vessel parts for classification purposes as most of the sherds fell within the undiagnostic category. A total of 89 diagnostic sherds were analysed and individual sherd summaries were recorded on the pottery summary sheet and registered into an Excel database for classification. The ranges of vessels represented by the material (**see Fig 29**) are as follows:

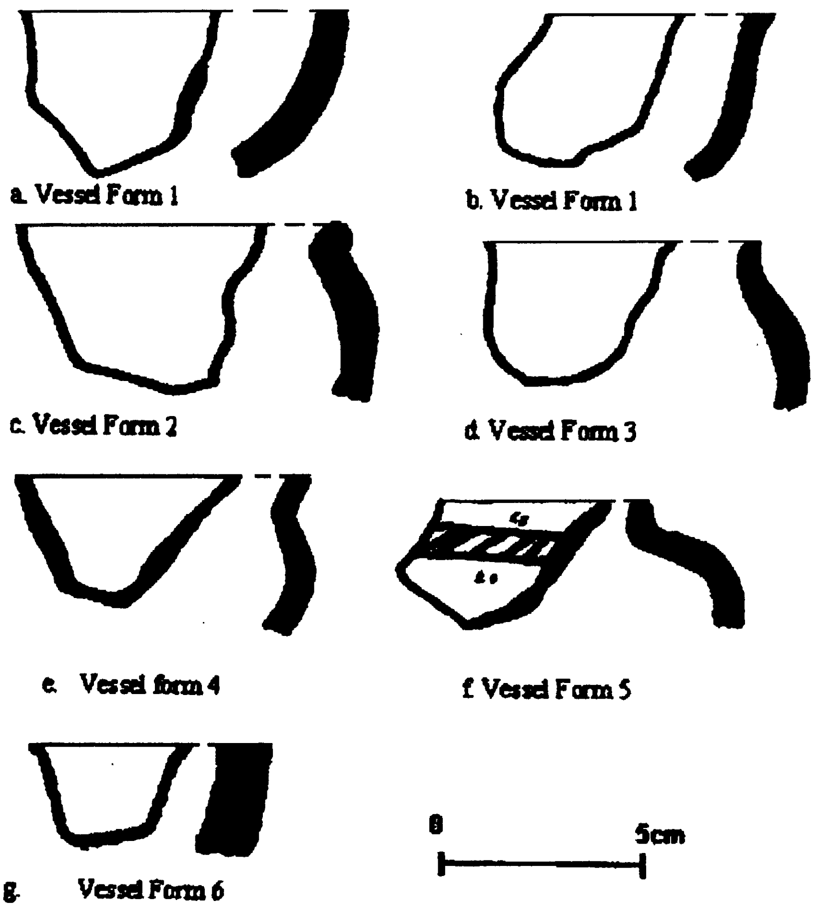
Bowls

1. open hemispherical bowls with straight or slightly out turned rims
2. necked bowls

Pots

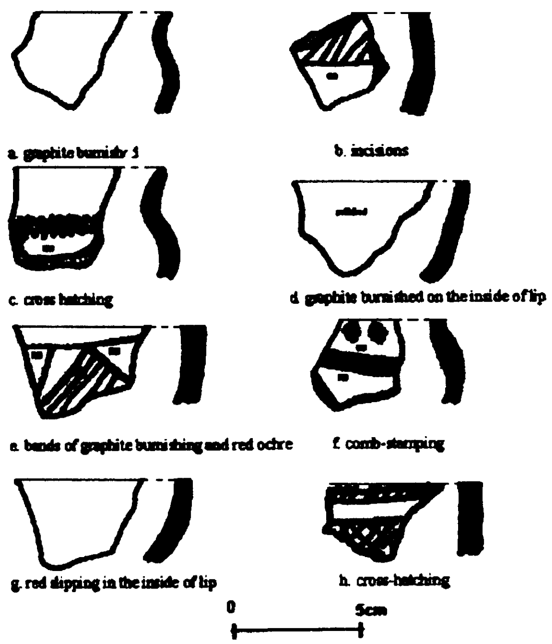
3. shouldered pots with insloping rims
4. shouldered pots with everted rims
5. pots with short tall or vertical necks.
6. indeterminate

Figure 29 **Vessel Forms from Baranda**



Shouldered pots had a high frequency when compared to other classes. In contrast, bowls dominate the ceramic assemblages analysed by Pikirayi (1993). Admittedly, Pikirayi's sample size was much larger than the one in this study. Plain pottery is infrequent with the majority of the pottery being lavishly graphite burnished imparting a very smooth and shiny surface. The brown to reddish brown colour demonstrates that the vessels were well fired. The decoration techniques employed by the potters at Baranda are comb-stamping and incisions (fine and broad lines) (**see Fig 30**). Most of these decoration techniques appear on pots. The majority of bowls are not decorated. Some of the pots and bowls are decorated with alternating bands of red slipping and graphite burnishing forming ornate patterns which are separated by broad lines of incision. Such pottery has very close affinities with that recovered at other Zimbabwe tradition sites in northern Zimbabwe such as Kasekete (Chirikure *et al.* 2001, Robinson 1965). The next step is to determine the relationship between Baranda and other Zimbabwe tradition sites in northern Zimbabwe.

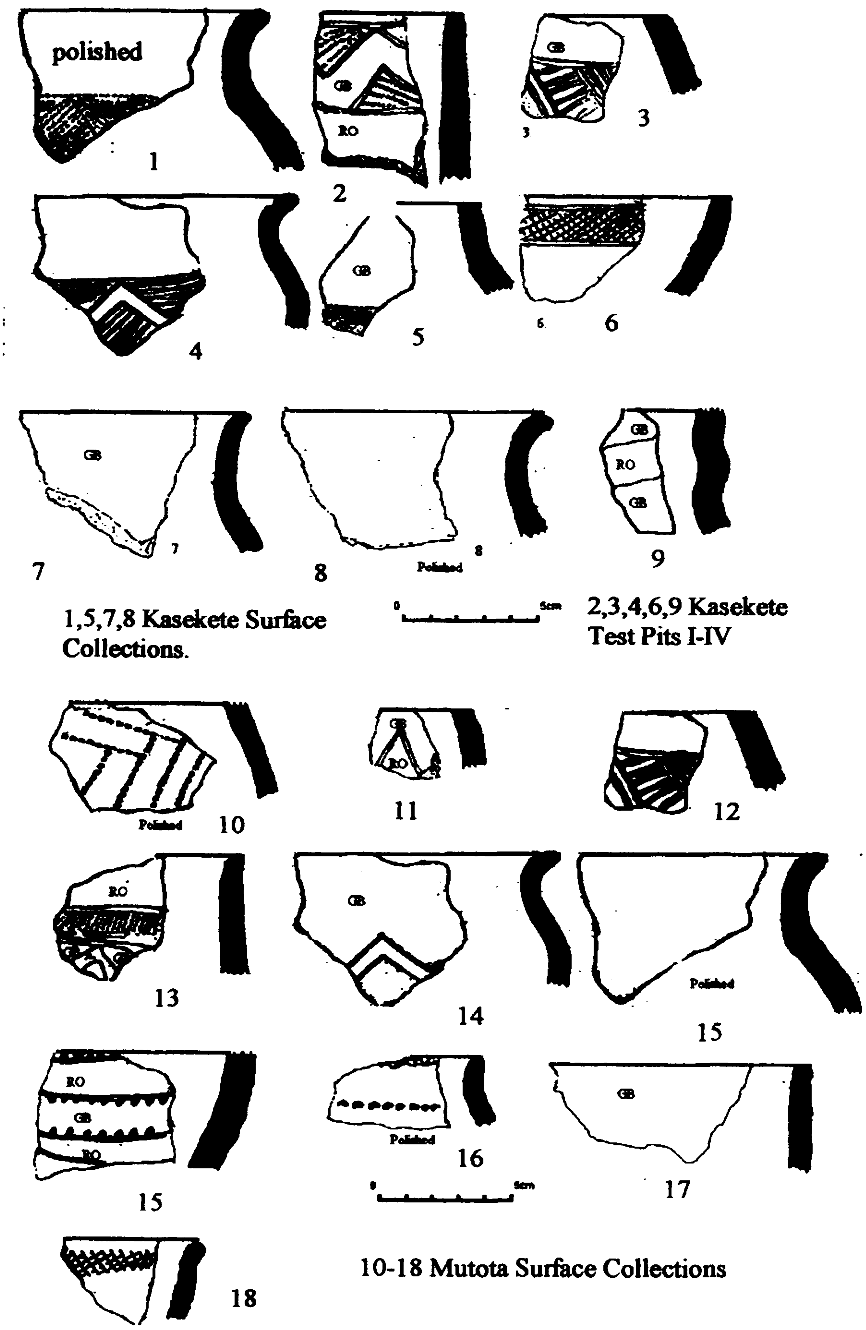
Figure 30 Decorated sherds from Baranda



Baranda within the wider context

The abundance of local artefacts and imports at Baranda suggests that it was both a state capital and a trading centre (Pikirayi 1993, p. 190). Local pottery recovered from the site has a striking resemblance to that from the terminal period at Great Zimbabwe and related sites in the north. Despite the absence of stone walls which are characteristic of many Zimbabwe tradition sites, Pikirayi (1993) proposes that structural changes ushered in by long-distance trade and internal politics led to a transformation in societal organisation which enabled the elites to have more control of the proceeds from trade. It is therefore necessary to place Baranda within the context of the Zimbabwe culture which dominated the cultural landscape of northern Zimbabwe from the 15^{th} century. The lavishly graphited local pottery recovered from Baranda and the typical pots with everted rims closely resemble that from the terminal period at Great Zimbabwe (Robinson's Period 4 pottery) (Robinson 1961a). This type of pottery has been found in abundance at walled Zimbabwe tradition sites in Mt Darwin such as Chomagora (Pikirayi 1993). Regionally, Baranda pottery has close parallels with that from other Mutapa capital sites such as Zvongombe in Centenary and Kasekete and Mutota in the mid-Zambezi valley indicating that it was part of the larger Zimbabwe tradition (Pwiti 1996). In addition, the pottery with alternating bands of red slipping and graphite burnishing has been recovered from Kasekete and Mutota, sites with possible Khami links (Chirikure *et al.* 2001, Robinson 1965).

Figure 31 **Pottery from Kasekete and Mutota, mid-Zambezi valley (after Chirikure *et al.* 2001)**



In line with other Zimbabwe tradition sites, cattle and agriculture seemed to have played an important role in the life of the inhabitants of Baranda. The bone analyses conducted at the Great Zimbabwe laboratory showed that cattle dominate the animal species recorded from Baranda (Pikirayi 1993). In addition there is some evidence of gold production as shown by crucible fragments. This largely confirms Pikirayi's definition of the site as representing the terminal phase of the Zimbabwe tradition in northern Zimbabwe. From a metallurgical viewpoint, Baranda is intriguing in that it is one of the very few Zimbabwe tradition sites to have yielded evidence of iron smelting within the settlement areas hitherto associated with smithing only (Childs and Killick 1993, Huffman 1993).

Summary

From a comparative perspective, there seem to be some apparent differences in both the scale and nature of iron production between Swart Village and Baranda. Trenches 1 and 2 at Swart Village produced twice the amount of slag recovered from all the trenches at Baranda. Production at Swart Village was either carried out for a long time or more intensive when compared to that at Baranda. The big slag lumps with semi-circular deformations that are characteristic of slag from Swart Village are not represented at Baranda. Also, the slag pieces at Baranda are smaller with the biggest pieces being approximately five by ten centimetres. There is variation in the size of tuyeres employed in the production process at the two sites. Whilst the internal diameter for tuyeres from Baranda is around 25 mm, those from Swart Village have twice that internal diameter. This suggests that Baranda and Swart Village represent two different smelting traditions which utilised furnaces of different sizes. Whilst there is an indication of some specialised areas at Baranda, at Swart Village this is not the case as all categories of material culture are represented everywhere on the site. Clearly, we are talking of societies at different levels of socio-political organisation. While Swart Village represent a hierarchically organised village society, Baranda was a capital of the Mutapa state. As leaders of large territories, Mutapa kings met their iron requirements through tribute unlike the "big men" at Swart Village who probably actively produced iron to enhance their position in society. It is therefore not surprising that there is a huge difference in the scale of production at the two sites. The cultural significance of these differences will be explored in Chapter Nine.

Chapter Six: The historical period: Nyanga and Wedza in perspective

Data collection: localised surveys, Nyanga

As with northern Zimbabwe, a desktop survey of documented and inventoried iron processing sites in lowland and upland Nyanga was carried out at the Museum of Human Sciences in Harare. This exercise was augmented by unpublished field notes and aerial photographs generously provided by Robert Soper of the Archaeology Unit, History Department, University of Zimbabwe. This preliminary scrutiny produced important data on the nature of iron extraction sites and their relation to other archaeological features such as agricultural terraces and settlement sites. In addition, this also yielded important information on the culture historical sequence of the area around Nyanga. A combination of desktop based study and museum data illustrated the existence of several sites dating to the Early Iron Age such as the Place of Offerings, Nyabombwe Gullies, and Nyabombwe River Valley. No absolute dates exist for these sites as none of them has been excavated. The typological studies of the pottery demonstrated that it was part of the Early Iron Age cultural package which included agriculture and sedentism (Soper 1971, Summers 1958). This is supported by the observation that the incisions and comb stamping designs found on ceramics from the Place of Offerings have affinities with similar pottery from securely dated sites such as the Gokomere Tunnel site in south central Zimbabwe (Huffman 1970, Robinson 1963). As with the Early Iron Age sites in southern Africa during this time, iron was worked at the Place of Offerings sites as shown by the recovery of slag and broken tuyeres. The inhabitants of these sites had contacts with the Indian Ocean as demonstrated by surface finds of glass. More importantly, finds of figurines were recovered at the site evoking questions regarding the control of ritual at the sites.

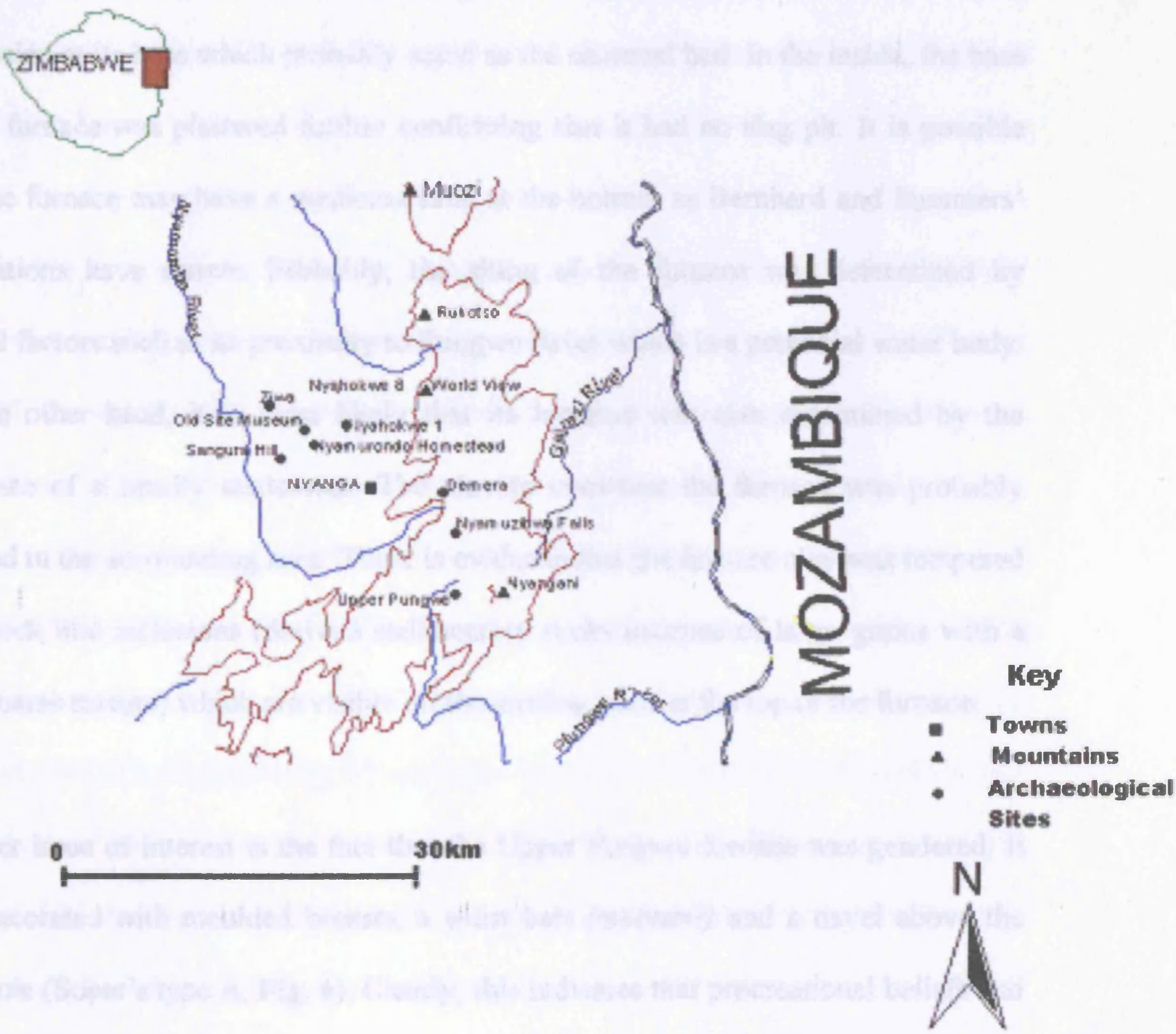
Overall, the existence of exotic goods, ritual objects and specialised craft activities suggests the development of accumulation of wealth during this period which had implications for the development of complex societies as was observed at Kadzi and Swart Village in northern Zimbabwe (Pwiti 2005) and at Schroda (Calabrese 2000, Hall 1987). A pedestrian survey of these sites showed that they have been disturbed by erosion since the 1960s, making it difficult to excavate them. On the other hand, the material from the surface only consisted of very small fragments of undiagnostic slag. Moreover, evidence of iron smelting was not reported from some of the Early Iron Age sites reported in the Nyanga area. Recent surveys by Soper (2002) also produced very few EIA sites but his fieldwork primarily focussed on the later stone structures and EIA sites were only recorded when encountered by chance.

However, from the 13th and 14th centuries AD, a new culture now known as the Nyanga Agricultural Complex developed in upland/highland and lowland Nyanga until its decline in the 19th century. Covering vast stretches of land in north-eastern Zimbabwe, it is believed that the Nyanga Agricultural Complex possibly constitutes the largest human modification of the landscape in southern African prehistory (Plug *et al.* 1997, Soper 2002, Summers 1958, p. ix). It consists in the main of pit structures, hilltop settlements and enclosures, which were used as dwellings for people and livestock while the terraces, cultivation ridges and furrows were used for agricultural purposes. Critical to these developments was the making and use of iron, which made it easier to cultivate, construct and alter the landscape of lowland and upland Nyanga to meet humanity's needs (Soper 2002). This significance of iron in the Nyanga Complex is demonstrated by the existence of many iron-processing sites ranging from slag scatters to groups of furnaces and smithing hearths, some associated with agricultural terraces and residential enclosures (Bernhard 1962, Soper 2002). Summers (1958, p. 101) posited that "what we have found is sufficient to permit us to conclude that the smelting of iron ore in primitive furnaces of the normal Shona type took place in the ruins during their occupation by the terrace builders". The excavations carried out by Bernhard (1962) and Summers (1958) showed that the furnaces had no slag pits but instead, they possessed a rake hole at the front where the slag and bloom were removed from the furnace. When considered from a diachronic perspective, this association of iron working with pit structures, irrigation furrows and terraces may throw some interesting light on the continuity and discontinuity of iron working techniques and the embedded socio-cultural factors.

Based on the results of desktop research, the areas with the greatest concentration of iron processing sites were targeted for localised intensive field walking including Ziwa Estate and Nyahokwe in the lowlands and Nyanga National Park and Nyanga Village in the uplands. Most of the archaeological sites in these areas are associated with the typical Nyanga pottery which is characterised by the presence of very few decorative motifs (Soper 2002). The grid references of sites marked on 1: 50 000 maps during the desktop surveys were used to locate the sites. At the individual sites, detailed intra-site surveys were conducted to record all the metal processing areas and their relationship with other features such as terraces and ridges. Obviously, one can question the contemporaneity of the furnaces and living areas given that no excavations were conducted for this research. However, since metallurgy was clearly an integral part of the agricultural landscape and not isolated, and that no other furnaces have been located, it would appear that furnaces and habitation areas are directly related (see Soper 2002 and Summers 1958, p.101).

The nine archaeometallurgical sites were recorded on site recording forms specially designed to capture the most salient features of each site. On the individual sites, archaeometallurgical finds were studied in relation to each other and samples enough for the scope of this project were collected for scientific investigation in the Wolfson Archaeological Science Laboratories at the UCL. In the end, samples for scientific analyses were taken from all the investigated sites, three in the uplands and six from the lowlands. The description of the sites and the context of the metallurgical remains follow below.

Figure 32 Map showing the research area in Nyanga



Upland Nyanga

1. Upper Pungwe **(see Fig. 33a)**

Located on the eastern bank of Pungwe River, metallurgical remains of considerable interest were recovered from this site. The site consisted of a partially collapsed low stone walled enclosure about four metres in diameter with an intact iron smelting furnace within it. The mouth of the enclosure and the frontal opening of the furnace faced the south-western direction which is opposite the prevailing wind direction. The furnace was well preserved and is surviving to its original height of one metre. At the base, the outside diameter of the furnace was also one metre **(see Figs 6 & 33a)**. Like most furnaces known in Zimbabwe during this time, the furnace had a very shallow depression at its base which probably acted as the charcoal bed. In the inside, the base of the furnace was plastered further confirming that it had no slag pit. It is possible that the furnace may have a medicine hole at the bottom as Bernhard and Summers' excavations have shown. Probably, the siting of the furnace was determined by several factors such as its proximity to Pungwe River which is a perennial water body. On the other hand, it is most likely that its location was also determined by the existence of a nearby settlement. The clay to construct the furnace was probably sourced in the surrounding area. There is evidence that the furnace clay was tempered with rock like inclusions (derived sedimentary rocks because of large grains with a very coarse texture) which are visible on the eroding parts at the top of the furnace.

Another issue of interest is the fact that the Upper Pungwe furnace was gendered. It was decorated with moulded breasts, a waist belt *(mutimwi)* and a navel above the rake hole (Soper's type A, **Fig. 6**). Clearly, this indicates that procreational beliefs and fertility symbolism were part of iron smelting in the Nyanga area. Broadly, these human features compare very well with those noted by Ndoro (1991) and Collett (1993) in the area around Great Zimbabwe and by Cooke (1959) in the Matopos. What is striking however is the observation that this furnace is in the vicinity (c. 25m) of two fairly large pit structures dating to the Nyanga complex (Summers 1958, Soper 2002). Also, the furnace is clearly visible from the pit structures and the furnace enclosure is too low to conceal anything. One could argue that perhaps the furnace and the pit structures were not contemporary. However, another factor to be considered is that there is no other known evidence of human occupation in the area surrounding the site which leaves the inhabitants of the pit structures as responsible for using the furnace. Moreover, finds of typical Upland Nyanga pottery were found in places which were not covered by grass showing that they were distributed across the whole ridge.

It has been proposed that most of the Upland Nyanga communities were self sufficient in almost everything implying that they also met their local iron requirements (Plug *et al.* 1997, Summers 1958). The association of the furnace with the pit structures shows potential variation in the relationship between the rituals and taboos linked with the craft and its spatial organisation. In this case it would seem that the metaphors of human reproduction were part of the iron working process yet the furnace was sited within the settlement area. The significance of this will be discussed after presenting the evidence from the remaining Nyanga sites (see also Chapter 8). Collapsed furnace remains were seen about 10 metres north of the enclosure. About fifteen metres southwest of the furnace enclosure lay a partially exposed rock surface with dolly holes or shallow holes in the rock surface. Usually, such holes were used in ore preparation as Swan (2002) has argued. Remains of possible ore were scattered around it and heavy lumps of rusty and magnetic "slag" were found. This could have been a "workshop" area where ore preparation and primary smithing were done. The samples for analysis were taken from fragments of ore, bloom and undiagnostic slag (see Chapter 7 for analyses and results).

2. Nyamuzihwa Falls

The site of Nyamuzihwa Falls lies about 8 kilometres from the site at Upper Pungwe further north. This iron extraction site was destroyed by road construction and remains of collapsed furnace walls, tuyere fragments and fairly large lumps of dense slag are scattered over the area. Whether there was an enclosure or not is unclear due to the disturbance of the site. Broken tuyere pieces, lumps of slag and vitrified furnace linings were collected for scientific examination in the laboratory. All these were associated with a depression in the ground that may have been the furnace base. There are no terraces in the vicinity and the site is approximately 5 km southeast of Demera near Nyanga Village.

3. Demera

Located on the cultivation terraces at Demera Hill, and lying about 12 kilometres southeast of Nyahokwe, the site consists of two separate low stone walled enclosures about 15 metres apart. The site is under threat from house construction in the nearby Rochdale area of Nyanga Village. The first enclosure contained an undecorated intact oval shaped smelting furnace with a diameter of 90 cm and a height of 75 cm (**see Fig 33b and c**). It had two tuyere holes at the end opposite the rake hole. Also, the mouths to the stone enclosure and the furnace were aligned in the same direction. However, no finds were visible due to dense vegetation cover and hence no samples were collected. A horseshoe shaped iron working structure surrounded by stone anvils and broken hammerstones was interpreted as a smithing hearth. It was located at the centre of the second enclosure which was about 3 metres in diameter. The hearth was 30 cm long and 50 cm wide. The walls, which were vitrified near the base, were about 15 cm thick. There was a sizeable amount of rusty and magnetic slag in the smithing enclosure and a small amount of this material was collected for scientific studies. The proximity of the smithing enclosure to the furnace demonstrates that iron smelting and smithing were done in related contexts. Demera Hill on which the site is located is replete with house floors and terraces tentatively indicating that the iron was probably used to cultivate the nearby terraces.

Lowland Nyanga

4. Nyahokwe 1

This site is located in the vicinity of cultivation terraces and stone cairns. It comprises collapsed furnace remains inside a low stone walled enclosure about three metres in diameter and 0. 50 m high. However, the original shape and type of the furnace were beyond recognition due to collapse. What is clear is the fact that the furnace wall was made from very coarse clay with large quartz clasts. Associated with this furnace were a few lumps of slag with charcoal impressions. The absence of concentrated scatters of iron working remains shows that the furnace may not have been used for a long time or that the scale of production was very low. The site lies about three kilometres east of the Old Site Museum at Nyahokwe. Fragments of furnace lining and pieces of slag were sampled for detailed metallurgical studies in the laboratory.

5. Nyahokwe 8

This site was of principal interest because of the presence of a fairly large smelting furnace (c. 70 cm at the base) flanked by a horseshoe shaped smithing hearth all located in a collapsed stone enclosure **(Fig 33d)**. Adjacent to the hearth was a fairly large block of dolerite stone, which may have been used as an anvil. The smithing hearth was c.40 cm long and 35 cm wide. On the other hand, it is possible that the hearth was actually a dilapidated furnace. However, the smaller dimensions of the structure would make it a smithing hearth rather than a furnace. Also, the structure is similar to the hearth documented at Demera. The furnace was oval (Soper's Type B) with two tuyere holes at the back and a large frontal with projecting arms. Unfortunately, no slag samples were found and thus material compatible with hearth/furnace lining was sampled for further investigations in the laboratory.

6. Nyamurondo Homestead

Iron working remains covering an area of approximately twenty to thirty square metres in size were observed at this site. The key features of the site include a partially collapsed oval shaped furnace within a stone wall enclosure about four metres in diameter. Outside the enclosure was another oval shaped iron working installation with two tuyere holes at the back standing in isolation. About five metres due south of this structure was a heap of broken tuyeres and a concentration of slag. The tuyeres had an internal diameter of 40 mm and an outside one of 50 mm. Some of the tuyeres were vitrified at the ends that had contact with the furnace reactions while others were not. Some of the slag was dense with a clearly visible flow texture compatible with tapped slag while the other slags looked like furnace bottoms (slag which solidified in the furnace). One issue of interest emerging from observations at this site was that while one furnace was located in an enclosure, the other one was not raising questions regarding the importance of such enclosures. Vitrified remains of the iron processing installations were picked for laboratory studies in addition to slag and furnace lining associated with the other furnace. The dense concentration of iron working remains shows that the production of iron at this site was probably large scale. In fact the site yielded the largest amount of metallurgical remains more than all the other sites from Nyanga studied for the purposes of this research.

8. Old Site Museum

The iron-working site comprised of a dilapidated furnace in a stone walled enclosure c. 0. 50 m high and 3-4 m in diameter. The furnace enclosure was about 10 metres away from settlement enclosures forming the cluster of ruins at Nyahokwe. The furnace approximates Soper's type two. It has been noted that the furnace used to be intact but was destroyed in the early 1970s during the war of liberation (Soper 2002). Very little iron working remains were observed at the site. Two fragments of slag with a well-defined flow texture were recovered near the mouth of the furnace. The furnace enclosure was akin to that of the stone walls suggesting a similar cultural tradition between the two. The site was about two kilometres northeast of Nyamurondo homestead.

7. Sangura Hill

The iron working remains consisted of an intact iron-smelting furnace belonging to Soper's type two. It was located in a low stone walled enclosure built of fairly large igneous rocks. The mouth of the furnace and enclosure faced different directions. No slag was recovered from this site though the furnace had evidence of vitrification. It is about one and half kilometres southwest of Nyamurondo homestead. Collapsed fragments of the furnace were collected to investigate the material used to construct the furnace as well as to determine whether it was used for iron production or not.

9. Ziwa 1

This site consisted of an intact smelting furnace in a stone enclosure about 30 cm high and three and half metres in diameter. The mouth of the enclosure was aligned in the same direction as that of the furnace. Visible in the enclosure were broken hammerstones and an anvil that was still intact. In addition, the smelting furnace had a moulded feature either representing female genitalia or a scarification associated with women's sexuality **(see Fig. 33g)**. What is interesting is the fact that the furnace did not have breasts or waist belts such as the one at Upper Pungwe showing that sexual symbolism was expressed differently even within this related culture.

Figure 33 Iron smelting furnaces from upland and lowland Nyanga

a) decorated oval shaped furnace from Upper Pungwe.

b). Iron smelting furnace, Demera Village

c). Smithing hearth, Demera, Nyanga

d) iron smelting furnace flanked by a possible smithing hearth, Nyahokwe 8

e). iron smelting furnace, Nyamurondo Homestead

f). collapsed iron smelting furnace, Old Site Museum. Note the enclosure still surviving to its original height.

g). decorated iron smelting furnace, Ziwa 1.

The key observations from the fieldwork were summarised and tabulated to evaluate any similarities and differences in the production of iron at Nyanga.

Table 9 Summary of field observations in lowland and upland Nyanga

Site Name	Furnace type	Decoration	Side Opening Visible	Absence/ Presence of Enclosure	Proximity to living area	Proximity to hearth	Materials Collected
Upper Pungwe	Oval	Waist belt, navel, breasts	Facing enclosure mouth (south-west)	Enclosure 4 m in diameter	Adjacent to two pit structures	Near a smithy. 5 m southwest	Furnace wall, ore remains, crown material
Nyamuzihwa Falls							Slag, broken tuyeres
Demera	Oval		Facing east opposite enclosure mouth	Enclosure 3. 5 m in diameter	Built on a terrace	3 m west of smithing hearth	Slag, furnace wall
Nyahokwe 1	Conical		collapsed	Enclosure 3 m in diameter			Slag, furnace wall
Nyahokwe 8	Conical		Facing enclosure mouth (west)			Flanked by a possible smithing hearth	Furnace wall, tuyere fragments
Old Site Museum	Oval			Enclosure 4 m in diameter	Adjacent to dry stone walls and terraces		slag
Sangura Hill	Conical		Partially collapsed	Enclosure 3. 5 m in diameter			5 m south of collapsed wall
Nyamurondo Homestead	Conical		collapsed	Enclosure 3 m in diameter		Surrounded by iron working debris	Slag, tuyeres, furnace wall
Ziwa 1	Conical	Female genitals?	Facing enclosure mouth (south)	Enclosure 3 m diameter			Furnace walling

Summary

Because of the dominance of pit structures, Soper (2002) has suggested that the original builders of the Nyanga Complex were probably not Shona. What is clear, however, is that the complex was assimilated by the Shona in the course of history although the period for these developments is unknown. By the late 19th century, the later part of the Nyanga Complex could be linked with the ancestors of the modern Unyama and Manyika populations. A number of observations can be made from the Nyanga material. Firstly, despite being associated with pit structures, terraces and enclosures in both lowland and upland Nyanga, there is a wide diversity of furnaces used. Does this mean that individual smelters used distinct furnace types or that the makers and users of the furnaces were different? Secondly, Nyanga is the only area known in Zimbabwe with iron smelting furnaces which are located in stone enclosures. Furthermore, some furnaces are decorated while others are not and in this case the motifs are different probably supporting the view that individual smelters expressed themselves differently. Probably, each smelting group had its own tradition which was different from that of its competitors and this local competition could have resulted in variation in iron working practices. This makes it interesting to compare iron working in Nyanga with that of other groups that existed in the plateau such as those who left their remains at localities such as Swart Village and Baranda. Equally interesting is the fact that some late nineteenth century furnaces in Nyanga are probably contemporary with the Wedza (Njanja) site which can provide some additional material on which to understand the nature of iron working in the historical societies. The time depth covered by the Nyanga material allows consideration of iron working in the area since the seventeenth century.

Wedza

While iron working among the Njanja people has been widely celebrated in terms of technical innovations and organisation of technology (at least in the historical sources;

Chapter 4), very little work has been done to study it from an archaeological or archaeometallurgical perspective. Apparently, most of what we know derives from ethnohistorical documents and oral traditions gathered from the Njanja area during the course of the twentieth century. As a result, little is known about the technical aspects of their iron production process and whether they were similar or different from those of their contemporaries and predecessors. This evokes questions regarding the efficiency of the process in domains such as slag-metal separation. Furthermore, it is essential to make an in depth study of the material remains from the production process with a view to complement the existing historical picture as well as to generate data on which to compare with other 18th and 19th century cases of iron working in localities such as that associated with the Nyanga Complex in the same region of eastern Zimbabwe. Arguably, this also affords an opportunity to assess whether the advances frequently associated with the craft in historical studies can be detected through the analyses of material remains from the production process within a framework of detailed archaeometallurgical studies. There is no doubt that when juxtaposed with the iron working in the preceding and contemporary periods, important information on the development of iron working technologies is produced. Only then can we be able to determine whether Njanja iron working inherited crucial aspects from the past smelting traditions or whether its so-called success story was a result of improvements which were novel to their precursors and contemporaries alike.

After the ethnographic study in Chapter Four, it was clear that Njanja oral traditions could be used with great success to situate the places where their ancestors produced and worked their iron. The geographical area between the Wedza range of mountains and the Njanja country has been categorically linked with their iron working activities. Surely, local people use their memories to elicit the location of places of historical interest on the physical landscape (Childs and de Maret, 1996, p.57). Of course, the use of historical data to understand crucial aspects of the past is no new thing and falls within the discipline now known as historical archaeology (Reid and Lane 2004). It was therefore thought necessary to use the historical information to identify the archaeological sites associated with Njanja iron production and to study the remains from the production process using standard archaeometallurgical procedures. During the process of gathering oral data, our Njanja informants revealed the existence of important iron production places such as Magangara, the former capital of Neshangwe, the founder of the Njanja confederacy. Ideally, it would have been important to survey such areas to understand how iron was worked and organised spatially in the early historical period. This endeavour was rendered impossible, however, by the fact that the Njanja were forcibly evicted from their original homelands to give way to commercial farming in the early 1920s (Posselt 1926). Now, most people just know of the existence of their original homelands but have never been there physically. This presented us with one unappealing prospect; a full scale archaeological survey of a thirty kilometre stretch of land to document the Njanja iron working from its material remains. Such an exercise was not possible in terms of the time and expenses that would have been needed leading to an alternative course of action. As we have seen in Chapter 4, our informants and documentary sources revealed that the Njanja practised a system of division of labour whereby one group mined the ore to carry home while the others smelted it to sell objects on the way home. Effectively, this meant that localised surveys of the landscape surrounding the mines should locate places where the Njanja also smelted their iron. It had emerged from the oral interviews carried out in the Wedza area that some local elders know not only the location of the historical iron mines but also the Njanja iron working sites in their vicinity. This made it possible for the first time to investigate the relationships between the ore from the mines and the Njanja smelting sites to determine whether such ore may have been exploited at the site and this is dealt with in Chapters 7 and 8.

In January of 2004, a preliminary reconnaissance was carried out in the area surrounding the Wedza Mountains to locate Njanja iron working sites. With the help of the local chiefs and government officials, some elders were asked to escort us to the famous iron mines on Gandamasungo (part of the Wedza Mountains). The oldest of our guides was the 79 year old Samaita who recollected that his father told him that the Njanja smelters frequently visited the mountains to obtain and smelt iron ore which only stopped after the area was developed for industrial gold mining and processing early in the 20th century. Luckily, some of the ancient iron extraction quarries were left unscathed by the large scale operations that are attested by the tunnels that were drilled into the mountain. Our local informants showed us two places near the summit of Gandamasungo which were quarries of different sizes. These were no doubt established in the process of iron ore extraction as large and small lumps of haematite mixed with host rocks were visible on the surface. Using the location of the mines as a centre point, a survey strategy of traversing one square kilometre transects on either side of the mountain was adopted. This also included the areas in which locals had observed iron working sites. In the end, one large scale iron smelting site was located near a small stream on the western edges of the mountain. However, both the mines and the site lacked any material culture such as pottery which could directly link them with the Njanja. As a result, a checklist with the characteristics of Njanja iron working revealed in Chapter 4 was designed to help in providing another source of evidence to cross check the claim in the oral traditions that the smelting site was Njanja. The checklist included features such as the furnace type, number of tuyeres, absence or presence of the rake hole and others. With these characteristics in mind, the site was intensively studied and remains were collected for further analyses in the laboratory.

Iron Mines on the Wedza Mountains

Detailed studies on the iron mines showed that the Njanja obtained their ore through mining it from shallow quarries such as the ones observed on Gandamasungo (**see Fig 34**). This open cast mining, however, was not very deep and people could easily work in them without endangering their lives. Of course, this is consistent with the technology used at the time which rendered it impossible to extract the ores from great depths. In this perspective, the Njanja may have realised the limitations of their mining technology. Nonetheless, the descriptions of the mines give an insight into the nature of iron extraction and the tools which were used. Whilst one of the mines is still intact, the other one did not survive the impact of illicit gold mining activities currently taking place on the mountain. The majority of unemployed youths from the area now earn a living through gold panning which at times involves reworking the disused European mine. One of our informants told us that a small group of people dug and vandalised the prehistoric iron mine believing that it was hiding a very rich gold vein. The dimensions and original depth of the quarry could not be established though large blocks of haematite lay adjacent to it. This was in contrast to the earth from the illicit mining activities which was still fresh and was carefully heaped on one side. The second mine produced vital information on the mining activities associated with the Njanja. From the surface, different grades of ores were visible with some containing less iron while others were clearly high grade ore. Basically, the mine consisted of a shallow quarry one and half metres deep and extending for a distance of seven metres east to west. There is no dump around the mine which is consistent with the observation that the miners most probably excavated a certain area, removed the ore and moved the debris to the back (south) leaving them with enough space to continue mining northwards. It was most likely that iron gads such as the ones reported by Mackenzie (1975) and picks were used to dig the mines. Whether the Njanja practised fire setting or not is not clear but the richness of the deposits and the depth of the mines would make that unnecessary. Eventually, ore samples were taken from possible high and low grade ores to compare them with those found at the smelting sites so as to determine whether the ore was likely used for smelting purposes. Also, this gave an opportunity to establish and understand the nature of the Wedza ores in terms of their bulk chemistry. It is also possible that smelters would at one time or another have utilised the nodules of haematite (of varying sizes) littered on the Wedza Mountains in their smelting activities. Again a few pieces of the material were collected to evaluate if they had potential to be ore.

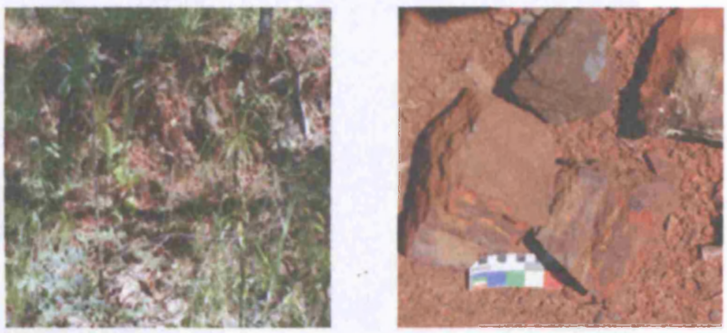


Figure 34 **a) northern view of quarry used to obtain iron. b) ore lumps on the surface, eastern side of the quarry**

About 200 m due west of the iron mines stood a mound of accumulated slag and other production remains which is believed to have been a Njanja production site. The mound is about 5 m by 6 m in extent. The mound is located approximately 30 m from a small stream suggesting that access to water may have determined the location of the iron smelting area. No intact furnaces were found but collapsed furnace walls both vitrified and unvitrified could be observed across the place. The furnace wall which was made of very coarse clay was on average 150 mm thick. These furnace wall remains were associated with broken tuyeres and tuyere plugs. Due to the incomplete nature of the evidence, we do not know any details regarding the size and shape of the furnaces. The most interesting feature regarding the tuyeres was that they were fused in pairs which confirm the historical information that the Njanja furnaces had three vents which accommodated a pair of tuyeres each. The internal diameter of the tuyeres was 35 mm while the external one was 45 mm. It is possible that the furnaces and tuyeres were made using the clay from the nearby swamps though compositional studies in the laboratory should show whether the clay was similar or different.

Figure 35 View of the iron smelting site from the north

Another category of iron working remains found at the site were nodules of partially reduced ore and raw ore. Clearly, the ore was haematite as shown by the red colour. It is also possible that the raw ore represented a poor grade that was thrown away before smelting. Retrieved from the same contexts with slag and collapsed furnace remains, these finds of ore were seen as essential in obtaining an understanding of the ores likely to have been used at the site and to determine whether they had any relationship with those from the mines.

Slags of different sizes formed a significant proportion of finds that had accumulated over time on the mound. Many types of slag were observed and the sizes ranged from large pieces (10 x 15 x 10 cm) to very small pieces less than one centimetre square. There were two types of slags on the large lumps: furnace bottoms/slags and what looked like tap/flow slag. On the whole, the furnace bottoms were larger than the tap slags. Some slag pieces had adhering portions of the vitrified furnace wall. The concentration of the iron working activities shows that iron was probably smelted over a long time at the site. About 2 m due east of the mound stood a large granite rock which had a smoothened surface. This raised questions about its possible use in smithing at the site. The area is heavily eroded and when cleaned to take photographs, a structure which assumed the shape of a bowl was clearly visible (**see Fig 36**). The wall thickness of the structure was 5 cm while its diameter was 28 cm although it is possible that the heavy erosion could have reduced part of the wall thickness. However, on the basis of a small diameter of the basin, the structure was interpreted as a smithing hearth. This is plausible in view of the fact that the structure is flanked by a huge and smooth rock that was likely used as an anvil. A few fragments of slag and what looked like a smithing hearth bottom (see Chapter 2) were found near the anvil. However, it is not clear whether the piece identified as a smithing hearth bottom was a product from that hearth or was just a discarded piece of smithing slag demonstrating the importance of subsequent metallurgical investigations in characterising the material. Overall, this discovery offered an opportunity to understand the nature of smithing at the site.

Figure 36 Iron working remains from Gandamasungo, Wedza Mountains

a. collapsed furnace **b. broken tuyeres**

c. a pair of fused tuyeres **d. tap slag**

e. possible smithing hearth base with anvil **f. possible smithing hearth base**

g. smithing hearth bottom

h. nodule of haematite

Summary

Although, there is no material culture such as pottery which can provide independent confirmation on whether the site was Njanja or not, the oral traditions used in locating it can be trusted. Since they date to fairly recent periods, it has been claimed that the level of distortion in them is minimal making them important sources of historical data (Beach 1983, 1994). Moreover, the nature of the remains fit those of the Njanja iron smelting. While the historical and ethnographic data is rich in information regarding the furnace types and the organisation of Njanja iron working, it is visibly silent on the technical details and yet to have a complete understanding of the past such information is vital. For example, was the success of the Njanja in terms of organisation (along industrial lines) (see Chapter Four) matched by a very efficient reduction of iron in the furnaces as well? This demonstrates the necessity of in depth laboratory studies. There is no doubt that the information obtaining from the exercise will improve our understanding of Njanja iron production. More importantly, since the Njanja iron working is almost contemporary with Nyanga iron working, it would be interesting to evaluate how smelting and smithing amongst these groups was similar or different. The next chapter focuses on the archaeometallurgical investigations of iron working remains collected from northern Zimbabwe, Wedza and Nyanga in order to characterise them and obtain data for comparative purposes.

Chapter Seven: Archaeometallurgical Investigations

Introduction

This chapter begins with an outline of archaeometallurgical theory before moving onto the laboratory techniques and the details of the actual metallurgical analyses. Iron working remains are not one of the classes of artefacts most frequently studied by archaeologists in searching for information about different aspects of past societies (Bachmann 1982, Miller *et al.* 2001, Morton and Wingrove 1969, Prendergast 1974). This is despite their great potential in addressing technological and socio-cultural questions regarding past societies. As seen in the previous chapter, the sites studied from the three regions have produced a large corpus of iron working debris that includes slags, broken tuyeres and remains of possible ore. This calls for a thorough archaeometallurgical study to characterise them and to determine the range of metal working episodes represented by various artefact suites. A sound sampling and analytical methodology was adopted to achieve this. As an initial screening and classification procedure, finds of metallurgical interest were categorized into groups such as smelting slags (tap and furnace slag), smithing slag, technical ceramics (broken tuyeres and furnace wall) and ore on the basis of their visual appearance and context. Adequate samples from each class of remains were subsequently analysed utilising optical metallography and XRF spectrometry. This exercise also allowed the understanding of the physical, microstructural and chemical relationships between metallurgical remains from related contexts at the individual sites. The data obtained from the laboratory studies allowed the definition of the stages in the production cycle epitomized by various suites of iron working remains. Fundamentally, this characterisation procedure promoted the reconstruction of the characteristics of iron working exhibited by the analysed materials.

Remains of iron working tell a story: archaeometallurgical theory

Archaeometallurgy is the study of prehistoric metal production and use through relics such as waste products from the production process and finished products that are surviving in the archaeological record (Miller and Killick 2004, Pleiner 2000, Rostoker and Bronson 1991). The most commonly encountered relics associated with prehistoric iron extraction and refining range from intact to collapsed furnaces, slag, broken tuyeres, remains of ore and finished products. These products of ancient metalworking processes have imprinted in their chemical compositions and microstructures a partial history of the transformations which they have undergone (Bachmann 1982, Killick 1991a, Morton and Wingrove 1972). When studied with appropriate analytical techniques in the laboratory, information on extant metallurgical processes is generated. This enhances our knowledge on human materials production, as well as facilitating the reconstruction of the place of metals in past societies (Bayley *et al.* 2001). Therefore, archaeometallurgical studies shed light on the conditions operating in extant furnaces, slag removal methods as well as the technological skills and capabilities of ancient smelters and smiths (Rostoker and Bronson 1991). On a broader scale, the production of metals such as iron was affected by cultural choices and decision making processes taken by human beings as they interacted with the world around them to produce iron (Barndon 2004, Childs and Herbert 2005, Childs and Killick 1993, de Barros 2000, Haaland 2004, Soper 2002). For instance, the decision to use one particular ore over another one was based on issues such as availability and the ease with which that ore could be worked. Archaeometallurgical studies therefore illuminate not only the technical parameters of metalworking in antiquity but also the opportunities, constraints and socio-cultural metaphors (through studying decorated furnaces) associated with the craft. Coupled to this is the fact that the distribution and consumption patterns of iron in the past can be inferred from studying the clustering of ferro-metallurgical debris through space and time thereby improving our knowledge of communities in prehistory. The similarities and differences of iron extraction and refining techniques in a given region can be used to reconstruct past metalworking traditions, in the process providing a basis on which to model the development of iron technology and its evolution in the past (Chirikure and Paynter 2002, Pleiner 2000, Prendergast 1974). Thus as a materials analysis research tool, archaeometallurgy allows us to have a holistic appraisal of iron technology and its socio-cultural trajectories. Obviously, this broadens our horizons regarding the exploitation of iron in extant communities.

Archaeometallurgical approaches and techniques

A variety of methods are available, including visual or macroscopic studies to the more scientific based analyses such as X-ray Fluorescence and optical microscopy. Although a wide range of physical, chemical and optical methods of metallurgical investigations exist, for the purposes of this research macroscopic observations, reflected light metallography and quantitative XRF were seen as the most suitable. Macroscopic studies of iron extraction remains can provide useful information on their surface condition, appearance, and relative density which helps in interpreting the series of processes embodied by various artefact types (Greenfield and Miller 2004). In addition, macroscopic studies enable the initial classification of the diverse iron working remains which act as a fundamental prerequisite for the subsequent metallurgical studies in the laboratory. As a result most researchers are agreed on the centrality of macroscopic observations in archaeometallurgy (Bayley *et al.* 2001, Ige and Rehren 2003, Killick 1996, Miller and Killick 2004, Miller and Van der Merwe 1994b, Tite 2001). When analysing a wide inventory of iron working debris from Ndondondwane, an archaeological site in South Africa, Greenfield and Miller (2004), were able to make a preliminary determination of the processes signified by the iron working remains from the site through macroscopic observations. For instance, they separated smelting from smithing slag which was later corroborated by optical metallographic and chemical investigations in the laboratory. Arguably, this shows that macroscopic observations are a very rewarding tool in reconstructing the stages in the production cycle attested by materials from the archaeological record.

Reflected light microscopy involves the viewing of polished sections under a microscope allowing the identification of mineralogical phases (a phase is a physically and chemically homogenous portion) present in a sample (Bachmann 1982, Joosten 2004, Killick 2004c). A comparative study of the phases present in an outwardly similar artefact suite such as slags can enable the establishment of groups based on microstructural similarities and differences. Undoubtedly, this can inform issues such as raw material usage and metallurgical traditions in a given cultural or historical period (Crew 1991, 1998, Miller 1995, Prendergast 1974). In addition, from the identification of rock and mineral inclusions, it may be possible to suggest possible ore sources by comparison with the local geology. This provides information on the skills, manipulation of furnace conditions, and smelting techniques mastered by prehistoric smelters and smiths. Schmidt (1997) employed reflected light microscopy with reasonable accuracy to characterise slag from iron smelting experiments and compared the results with those of his analyses from Iron Age slag to gain an understanding of iron working in the last two millennia in one region of Tanzania. On the basis of the phase composition of the slags and broken tuyeres, Schmidt modelled the potential development in iron working over time. The major advantage of using reflected light microscopy over other phase identification methods such as XRD is that in addition to being sensitive to small quantities of phases present in a sample, the texture of a sample can be detected and interpreted which XRD does not always permit (Bousfield 1972, Killick 1996).

However, reflected light metallography is limited when compared to Scanning Electron Microscopy which provides a very large depth of focus and a high magnification range. Also, X-ray beams which are produced when the electron beam hits the sample can be used to identify and image specific elemental distributions in a specimen (Killick 1996, Tite 2001, Vander Voort 1999). Although, SEM possesses these advantages over reflected light metallography, it is limited by its inability to reproduce colour which is achievable when using reflected light microscopes (Killick 1996, pp. 215-6). In addition, to being cheap and easily available, optical microscopy is also very effective in characterising metallurgical remains and defining the processes which they represent in the iron working cycle. Furthermore, XRF can produce more reliable quantitative information on the elemental composition of a sample than is possible with SEM (Bayley *et al.* 2001, Tite 2001) (see below). It was therefore felt that a combination of reflected light metallography and XRF would be sufficient for the purposes of this study.

Quantitative XRF is a technique used to determine the elemental composition of a sample including major, minor and trace elements (Tite 2001). XRF interprets the characteristic radiation emitted by elements of a sample upon excitation to identify and quantify the elements present (Bayley *et al.* 2001). A beam of X-rays is irradiated on a sample which then emits a spectrum that contains peaks for each of the elements present, revealing its overall elemental composition. In the case of prehistoric iron smelting, XRF can be used to establish the relationships between the ores that were smelted, the slags, the technical ceramics present and the finished metal produced allowing a reconstruction of furnace conditions and the treatment of ores and metals in the deeper past (Bachmann 1982, Brothwell and Pollard 2001, Miller and Killick 2004, Morton and Wingrove 1972). On the basis of similarities in the principal elements of ore and slag samples from the Veluwe area of the Netherlands, Joosten (2004) was able to conclude that bog ores were likely to have been utilised by successive smelters in the area. On their part, Morton and Wingrove (1969) combined optical microscopy with XRF to correlate the slags and ores from a Roman site in Colchester. As a result, they noted that the bog ores that were recovered in association with the slag at the site could have been exploited by Roman smelters in prehistory owing to the similarity in major, minor and trace element signatures of the ores and the slag (Morton and Wingrove 1969). When viewed in the above light, it becomes apparent that a combination of optical microscopy, XRF, field observations and macroscopic analyses is best suited for the reconstruction of prehistoric iron working processes.

Context, Sampling Procedures and Macroscopic observations

The metallurgical remains for analyses from the three case studies were retrieved from various archaeological and historical contexts using different methods. For northern Zimbabwe, the samples were obtained during the stratigraphic excavations conducted at the sites of Swart Village and Baranda (Chapter 5). In the case of eastern Zimbabwe (Nyanga and Wedza) (Chapter 6), the iron working remains for analyses were recovered during controlled surface collections. The major criticism levelled against the use of surface collections in any kind of archaeological enquiry is that they have a geographical context but no certain archaeological association (Chirikure and Paynter 2002, p. 3, Fletcher and Locks 1996, p.62). However, this limitation is considered unimportant for the purposes of this research because the archaeometallurgical remains for analysis were collected from secure contexts associated with well-defined metal working areas such as furnaces. In fact, carefully collected surface collections can be more informative than some excavated assemblages from disturbed and mixed archaeological contexts (Fletcher and Locks 1996).

Because of the filter or taphonomic processes in operation in the archaeological record, the retrieval of entire populations of material is absolutely impossible. Thus, inherently archaeologists are dealing with fractions or parts of the population that once existed. Even with what has survived from the past, limitations of time and resources do not allow the study of all the discovered sites or assemblages recovered during surveys or excavations (Drennan 1994, p. 82, Fletcher and Locks 1996, Orton 2000, Shennan 1997). It is therefore essential to make inferences about a total population on the basis of a sample portion of elements selected from it. The rationale of sampling is to enable reliable inferences regarding an entire population by analysing a small proportion of the available material. It is important to select the samples in a way that maximises their chance of accurately representing the entire population. Ideally, the larger the sample size the more reliable will be the data and interpretations derived from it. As a result, the onus is upon researchers to make their samples as representative as possible. Despite the difficulty of defining a representative sample, Fletcher and Locks (1996) argue that it is the one which yields a maximum amount of information when analysed. Most researchers are agreed that a twenty five percent sample usually allows the making of inferences within a reasonable degree of confidence (Drennan 1994, p. 85, Orton 2000, Shennan 1997).

There are many sampling techniques which can aid archaeologists to make reliable inferences from their data. These range from the non-scientific grab samples to the more statistical methods derived from probability theory such as random and systematic sampling. Grab or judgement samples are limited in that they do not allow statements to be made about samples that were not included in the sample, which can be achieved through randomly or systematically selected samples (Orton 2000, Shennan 1997). Since the morphology of different suites of iron working remains can be linked to technological process and human activity, the first and perhaps most important step in sampling archaeometallurgical remains is to contextually group them into strata on the basis of their visual appearance (Crew 1991, Pleiner 2000, Greenfield and Miller 2004, Miller and Killick 2004, Rehder 2000). Because iron extraction debris such as slags, remains of ore and refractory/technical ceramics are part of a continuum in the production process, this procedure of classifying them (on the basis of visual appearance) enables the reconstruction of the stages in the *chaine opératoire* represented by the materials. For the purposes of this study, the iron extraction remains were first grouped into groups such as smelting slags (tap and furnace slags), smithing slags, crown material, remains of ore and technical ceramics (tuyeres and furnace wall). In the end, the samples for analyses were randomly selected from the different strata and analysed to gain specific technical data. This analytical procedure also allowed the re-assessment of the morphological groups and whether they are appropriate when studying prehistoric iron working. The diverse categories and their definitions are as follows:

a) Furnace wall: these are lumps of technical ceramic that were once part of the superstructure of the furnace. They were exposed to very high temperatures making them durable. In some instances they were slag coated and bloated in the interior.

Figure 37 **Vitrified furnace wall from Nyamurondo Homestead**

b) Tuyere fragments: these are from cylindrical ceramic pipes that supplied the air blast to the reactions in the furnace. They were vitrified and slagged on the distal end that had direct contact with the heat inside the furnace and unvitrified on the proximal ends that were close to the bellows.

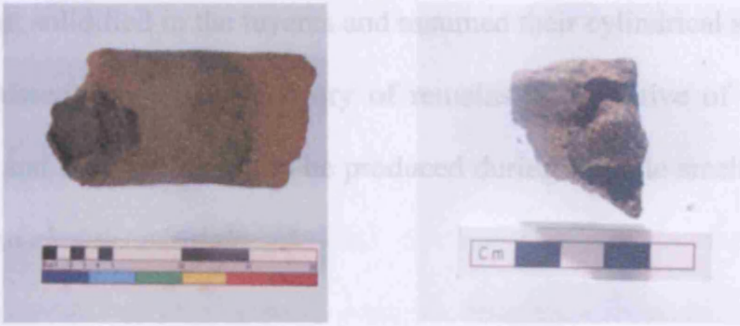


Figure 38 **Tuyere fragments from Swart Village and Baranda**

c) Tap/Flow slag: this group is made up of slag which had clearly defined flow structures typical of tap slag. The surface of the flows was either rippled or smooth. However, no direct evidence for tapping was recovered though evidently the slag had run off from the furnace in a liquid state and on cooling it preserved a flow structure akin to that of lava flow. The existence of slag with a clearly defined flow structure does not necessarily indicate the existence of slag tapping at a site. This is because non-slag tapping furnaces are known to produce occasionally some "tap/flow" slag (Schmidt 1997). Quite clearly, finds of significant amounts of tap slag are diagnostic of iron smelting in the archaeological record.

Figure 39 **Tap/flow slag, Swart Village**

d) Furnace slag: Furnace slag is differentiated from tap slag by the lack of flow structures, and supposed to have cooled within the furnace. Its morphology is characterised by irregular shapes, often containing charcoal impressions or adhering furnace wall material. This category also included tuyere plugs; these are pieces of molten slag that solidified in the tuyeres and assumed their cylindrical shape. Like the tap slags discussed above, this category of remains is indicative of iron smelting. Furnace slags and tap/flow slags can be produced during a single smelt and are often part of the same *chaîne opératoire*.

Figure 40 Furnace slag with adhering ceramic from Wedza

e) Smithing slag: On the basis of external morphological appearance, some slags had a plano-convex shape consistent with smithing hearth bottoms earlier discussed in Chapter Two. The surfaces of such finds were undulating while the bases had charcoal impressions. However, the smithing bottoms from southern African archaeological sites are in some cases not as well developed and concave as similar material from Europe discussed by authorities such as Pleiner (2000) and Serneels and Perret (2003) (see Greenfield and Miller 2004 and Miller and Killick 2004). There is also another group of slag which was tentatively classified as smithing slag because it did not possess the characteristics of either tap or furnace slag. Instead, the slag was rusty and magnetic probably with inclusions of metallic iron. All finds classified as smithing slag were recovered in contexts linked with bloom refining activities at the sites. For example, a smithing hearth bottom was retrieved adjacent to a smithing hearth and anvil in Wedza (Chapter Six). Similar material was also recovered at Demera. At Swart Village and Baranda, smithing slags were found in association with hammerstones and magnetic scales which are possible hammerscale.

Figure 41 **Smithing hearth bottom from Wedza**

f) Crown material: this category of materials was heavy probably with a sizeable quantity of metallic iron interspersed with slag inclusions, charcoal and porosity. Crown material is usually knocked off the original bloom and discarded during primary smithing or cleaning of the bloom; it is more magnetic when compared to other types of slag. Technically, it stands between furnace slag and the bloom; archaeologically, it is closely related to primary smithing. Thus, crown material, a product from the smelting furnace represents fragments that are knocked off the bloom in preparation for primary smithing, hence its association with smithing rather than smelting.

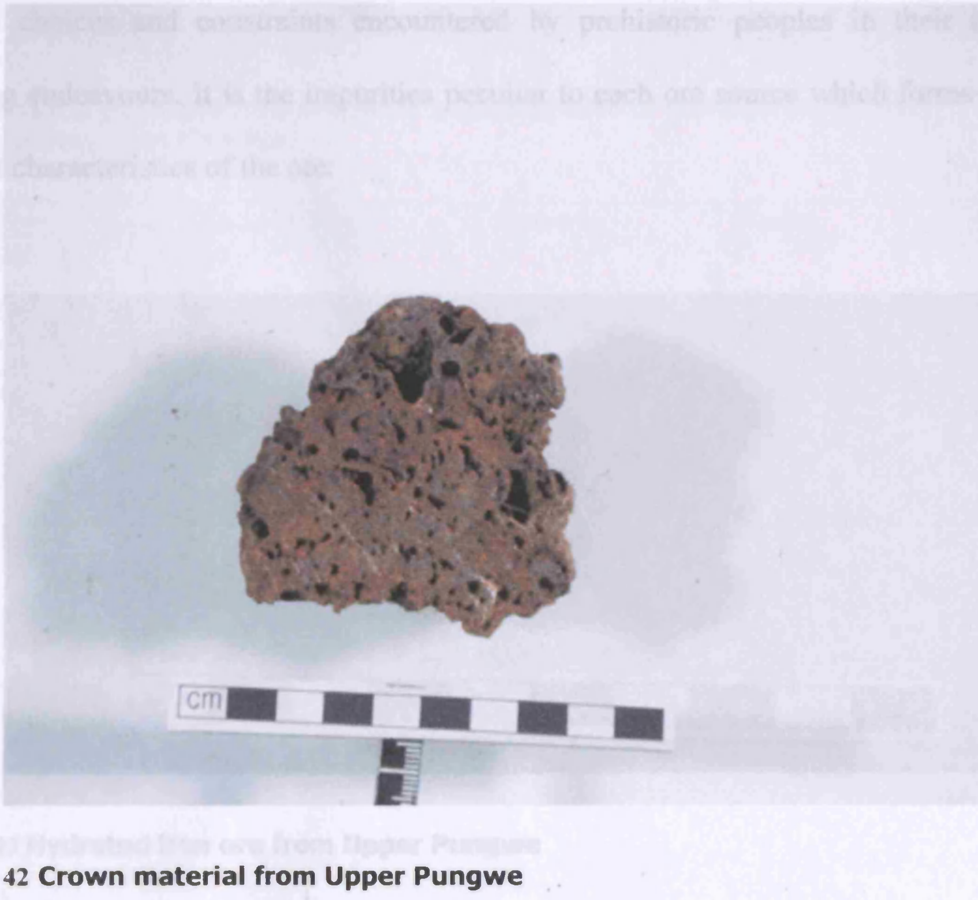


Figure 42 **Crown material from Upper Pungwe**

g) Ore: Finds of ores comprised two categories, raw ore and partially reduced ores. Raw ores took the form of hydrated iron oxide, banded iron stone and laterite. In contrast, partially reduced ores had a purplish colour showing that they had been exposed to the furnace reactions. Some of the partially reduced ore fragments had slag encrustations, further confirming that they had passed through the furnace. Both categories were recovered in association with slag and may have been linked to the metal working activities at the sites. Proper care must be taken in interpreting remains of iron rich stones found on archaeological sites for they may have been used for other purposes such as making pigments (Calabrese 2000, Miller 2001). This calls for a contextual approach in interpreting these finds and their association with collapsed furnaces and tuyeres proves beyond doubt that they may have been linked with metallurgical processes. All finds of ore are potentially interesting as they shed light on the choices and constraints encountered by prehistoric peoples in their iron working endeavours. It is the impurities peculiar to each ore source which forms the distinct characteristics of the ore.

Figure 43 **Hydrated iron ore from Upper Pungwe**

i) Undiagnostic: this refers to iron working remains which could not be fitted into any of the above groups with confidence because the specific metallurgical phases which they represent in the iron production cycle were not immediately recognisable.

To facilitate the selection of adequate samples for detailed metallurgical analyses in the laboratory, these different types of iron working remains were weighed, tabulated and expressed as a percentage of the recovered population. However, the material from the Old Site Museum, Nyahokwe 8, Ziwa 1 and Sangura Hill all from Nyanga was less than one kilogram and the sites are not represented in the tables even though the material was studied.

Table 10 The weight and frequencies of the categories of remains from Swart Village, Baranda and Wedza.

Category of remains	**Swart Village**		**Baranda**		**Wedza**	
Furnace wall	0. 8 kg	1%	1 kg	4%	2 kg	5%
Tuyeres	15 kg	19%	2 kg	7%	5 kg	11%
Tap/flow slag	35 kg	44%	5 kg	19%	21 kg	47%
Furnace slag	20 kg	25%	15 kg	56%	10 kg	23%
Crown material/Smithing slag	7 kg	9%	1 kg	4%	3 kg	7%
Ore	0. 9 kg	1%	0. 8 kg	3%	2 kg	5%
Undiagnostic	1 kg	1%	2 kg	7%	1 kg	2%
Total	**78.8 kg**	**100%**	**26.8 kg**	**100%**	**44 kg**	**100%**

Table 11 The weight and frequency of the categories of iron working remains from Nyanga.

Category of remains	Demera		Upper Pungwe		Nyamuzihwa Falls		Nyamurondo Homestead	
Furnace wall			2 kg	16%			7 kg	14%
Tuyeres							5 kg	11%
Tap/flow slag					3 kg	18%	12 kg	27%
Furnace slag	5 kg	33%			11 kg	65%	20 kg	44%
Crown material/Smithing slag	8 kg	53%	10 kg	74%	2 kg	12%		
Ore			0. 8g	5%				
Undiagnostic	2 kg	14%	0. 8g	5%	1 kg	5%	2 kg	4%
Total	**15 kg**	**100 %**	**13.6 kg**	**100%**	**17 kg**	**100%**	**46. 9 kg**	**100%**

Enough samples of each category from the selected sites were randomly chosen and prepared as polished blocks for reflected light microscopy and as pressed pellets for quantitative XRF. For categories of materials totalling 10 kg or less, a seventy five percent sample was selected for analysis while fifty percent of the samples were chosen for categories weighing more than ten kilograms but less than twenty kilograms. The results of the analytical procedures follow below.

Reflected Light Microscopy: Mineralogical and microsctructural analyses of iron working remains

The samples selected for analysis were cut using a diamond saw, mounted in epoxy resin and ground following standard metallographic procedures (Scott 1991, Vander Voort 1999). The samples were then studied using an Olympus microscope. Mineralogically, a variety of phases such as metallic iron, wuestite, interstitial glass, hercynite, leucite and ulvite spinels can be found in a sample of slag depending on the furnace chemistry. Under the microscope, the different phases present in a sample appear as varying shades of mostly grey with wuestite appearing as light grey while metallic iron is bright white (Morton and Wingrove 1969). Fayalite appears as medium grey with the glassy matrix being dark grey while the porosity is black. Other phases such as spinels appear as angular crystals within these colour gradations. The existence of these phases in different samples can reveal the conditions of operation in the furnaces. For example under strongly reducing conditions, wuestite is the predominant iron oxide in slags while under less reducing conditions magnetite can predominate (Greenfield and Miller 2004). Usually, big and blocky crystals indicate slow cooling while small, skeletal, elongated and dendritic crystals are indicative of more rapid cooling. Furthermore, the rapid cooling of slags can be identified through the existence of fayalite having formed perpendicular to the cooling front or surface, a structure known as spinifex (Ige and Rehren 2003, Killick 1996). The relative proportions of phases present in a sample reveal whether the reduction was efficient or not. According to Morton and Wingrove (1969), high wuestite levels in a sample indicate inefficient reduction while low wuestite levels denote efficient reduction.

Based on the microstructural differences, the different stages in the production process represented by materials such as slags can be deduced. Tapped or flow slags possess magnetite skins or oxidation layers which separate individual slag flows (Joosten 2004, Miller and Killick 2004, Okafor 1993), while these features are absent in furnace and smithing slags. In some cases slags can contain remains of partially reduced ore which can allow the identification of the types of ores utilised in extant furnaces. Greenfield and Miller (2004) have identified small particles of partially reduced ore which they identified as haematite embedded in the slags from

Ndondondwane. Again such types of slags are diagnostic of iron smelting. Smithing slags can also be identified on the basis of their microstructures. The presence of significant amounts of leucitic phases in samples is often indicative of iron smithing slag. It must be mentioned that smithing and smelting slags often mineralogically grade into each other so that it is difficult to get any meaningful information from analyses of isolated metallurgical finds without a well documented context (Bachmann 1982, Miller and Killick 2004, Serneels and Perret 2003). This results from the fact that some smelting slags find their way into the forging hearths attached to the bloom and would maintain their previous microstructure. However, when combined with contextual evidence, smithing slag can be identified within a reasonable degree of accuracy. Crown material is also indicative of primary smithing although it is produced during smelting. There is a continuum from crown material to some types of furnace slags which contain grains of metallic iron which would not have coalesced, the only differentiating factor being differences in sizes and proportions of iron particles in the two types of slag. Furnace slags are typically blocky while crown material often forms smaller fragments.

Issues such as clay selection and the use of temper to increase the refractory nature of the clays used to make furnace walls and tuyeres can be resolved with reflected light microscopy. Under the microscope, deliberately added tempering material can look quite different from natural clay inclusions. For example, intentionally added quartz or rock grains are often crushed and angular due to deliberate human action. In contrast, the inclusions present in natural clay often will be rounded because of natural weathering. Furthermore, it is possible to determine the similarities and differences between the clays used for making tuyeres and furnace walls at a given site. Some smelters are known to have made their tuyeres and furnaces with different clays; exploiting the specific advantages in the physical properties of each type (Childs 1989).

Iron ores can be successfully characterised using reflected light microscopy. In high grade ores, iron oxides predominate with very low quantities of siliceous materials. Inversely, low grade ores are characterised by a low iron oxide composition and a higher concentration of the gangue materials.

Chemical Analyses

XRF samples were sectioned off the same materials that were used to prepare polished blocks for reflected light microscopy. They were crushed and milled in a tungsten carbide mortar, left overnight to dry in the oven at 105° Celsius and prepared as pressed pellets for bulk chemical analyses. The quantitative analyses were performed by Energy Dispersive X-ray Fluorescence Spectrometry (ED-XRF) in a Spectro Xlab 2000 machine, using a calibration method specifically designed for iron rich materials, which evaluates the measured values against certified reference materials (CRM) (Veldhuijzen 2003). The chemical analysis was done as a characterisation process, with a view to identify similarities and differences between the various slag sites and the slag and ore samples from the same site. The compositions of iron slags can be quite variable and reflect the various inputs of materials in the bloomery furnaces and forges during metal working. Chemical analyses were also conducted in order to reconstruct the specific technical aspects of iron working at the selected sites such as the efficiency of the process, the types of ores utilised and the contributions of fuel ash and technical ceramics in the slagging process. The elemental composition of furnace linings was also determined with a view to establish the possible hereditary relationship between the ore, slag and furnace.

Results: Swart Village

Table 12 shows average XRF results per materials from Swart Village. See Appendix for all the results.

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	FeO	Total
SV TS	0.51	2.02	6.63	22.73	0.26	1.38	2.47	0.23	10.75	60.81	108.30
SV FS	0.48	1.78	4.38	19.41	0.35	0.80	1.45	0.11	5.52	73.29	107.43
SV SS/CM	0.44	1.86	5.06	16.95	0.27	0.57	0.94	0.09	5.46	74.43	105.85
SV UD	0.70	2.01	5.68	21.37	0.64	1.25	2.19	0.17	7.34	64.70	106.04
SV FW	2.01	1.31	21.80	60.73	0.22	1.65	0.63	0.59	0.06	5.17	92.94
SV TY	1.22	1.10	21.00	52.77	0.97	1.13	1.68	0.78	0.06	8.32	87.83
SV ORE	0.51	1.12	1.87	3.94	0.09	0.10	0.28	0.93	9.39	79.68	98.77

Key: SV = Swart Village, TS = tap slag, FS = Furnace slag, SS/CM = smithing slag/ crown material, UD = undiagnostic, FW = furnace wall, TY = tuyere

Tap/Flow Slag

The mineralogy and chemical composition of the flow slag samples fell within the range of typical bloomery slag. Microstructurally, wuestite (50-60%) was the most dominant phase followed by fayalite (25-30%) and glassy phases (5-10%). This microscopic observation is matched by the average FeO content of around 61 wt% detected through compositional analyses. The tap slags are relatively low in alumina (6 to 7 wt% average) with silica being close to four times that amount with an average of c. 23 wt%. Normally, alumina and silica are derived from the gangue in the ore and a small proportion of the ceramic material. The eroded nature of the tuyeres shows that they contributed to the furnace reactions. There is a high level of manganese (c. 11 wt%) in the slags which assumed the place of iron oxide in the chemical partitioning ensuring the achievement of higher yields in the furnaces. The samples also contain enriched levels of calcium and potassium, elements which typically derive from the fuel ash. This enrichment of manganese and typical fuel ash oxides is consistent with the identification of this material as tap slag which represents the most fluid part of the furnace charge, dominated by relatively high glass content and comprising proportionately more of the fluxing alkali and earth alkali metal oxides. Furthermore, the tap slags had clear oxidation layers that separated individual slag flows. Normally, slag which cooled outside the furnace develops such a microstructure on exposure to the air outside the furnace (Crew 1998, Stanway 2003). It may be plausible to assume that tapping or a technology that produced a lot of fluid slag was a more regular part of the process at Swart Village. Barium, strontium and zirconium (see Appendix 3) are also present in the tap slags from Swart Village. These trace elements show the possible contribution of technical ceramics in the slagging process since they are derived from the technical ceramics.

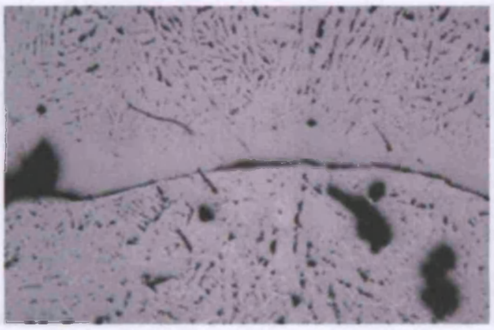
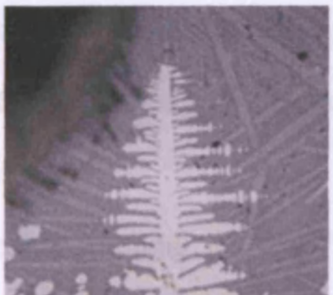


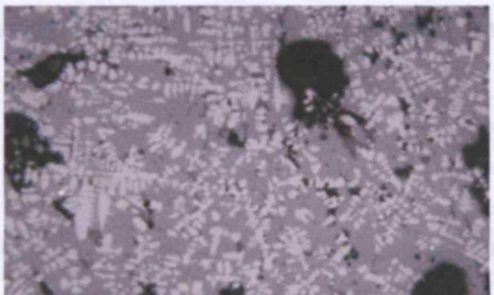
Figure 44 Photomicrograph of tap slag sample from Swart Village Trench 1, Layer 3 (x50 mag). Note the two slag flows separated by the magnetite skin and the perpendicular nature of the fayalite

Furnace slag

Mineralogically, this type of slag was characterised by the dominance of wuestite (65%), fayalite (25%), glassy matrix 5% and porosity (5%) though in some instances minute particles of metallic iron are visible. The blocky fayalite and wuestite in a sizeable number of samples shows that the majority of the samples had cooled slowly while others had cooled rapidly as indicated by the dendritic wuestite and the skeletal fayalitic phases. Chemically, there is variation in the concentrations of principal components of this category of metallurgical remains compared to the tap slags. For instance, furnace slags have a higher average FeO content (c 73 wt%) and a lower manganese content (5 to 6 wt%). The calcium and potassium levels are lower in furnace slags than in the tap slags. This difference is expected because despite being part of the same continuum, the more fluid tap slag drains away from the furnace with proportionately more of the fluxing alkali oxides. Such an observation is well supported by the different morphologies exhibited by the suites of slags: tap slag has a high glass content and thus is more fluid. The similarity in both trace elements such as barium and strontium and major elements, however, suggest that chemically tap slags and furnace slags were a result of the same process.



(a) Trench 2, Layer 2, x50 mag



(b) Trench 2 Layer 3, x20 mag

Figure 45 Photomicrographs of furnace slag from Swart Village (a) dendritic wuestite intergrown with skeletal fayalite and (b) dendrites of wuestite in a fayalitic matrix.

Smithing slag and crown material

These materials are discussed jointly here because of their association with the process of smithing despite being systematically different in their origin; crown material is a product from the smelting furnace while smithing slag is normally derived from smithing hearths. Microscopically, the major phases visible in the crown material are between 25 and 40% metallic iron, 20 and 40% each for wuestite and fayalite and 10% porosity. With the microstructure being similar to the other types of slag, the only differentiating factor appears to be the relatively high level of metallic iron in crown material. The fayalite was blocky indicating that the samples had cooled slowly and possibly inside the furnace/hearth. Clearly, the pieces of crown material analysed do not approximate real blooms for they are unlikely to have survived as they were converted into tools. This material is consistent with fragments knocked off the original bloom and thus may be indicative of primary smithing in the archaeological record or just "cleaning" of the bloom before it was passed somewhere else. The smithing slag was similar to both the tap and furnace slags being dominated by high wuestite and blocky fayalite. Some of the smithing slags contained small amounts of metallic iron which were heavily corroded.

Chemically, smithing slags and crown material are two distinct groups; the crown material is very rich in iron (expressed in the tables as iron oxide, but present in parts as metallic iron), reaching 85 wt% FeO (see Appendix 2). However, in **table 13** the average FeO has been lowered by the inclusion of smithing slag which has low levels of metallic iron. All other oxides are accordingly present at lower levels, with the same differential depletion observed earlier for the difference between tap slag and furnace slag. This underlines the fundamental relationship between all these slag types, with tap slag and the bloom forming the extreme ends of a stepped continuum.

Undiagnostic

The last group of slag could not be assigned to any of the above types with certainty. Mineralogically, the slags in this group were more closely related to the furnace slags being dominated by wuestite and fayalitic phases. Chemically, undiagnostic slags are marked by an average FeO content of close to c. 64 wt%) between tap slag and furnace slags. Also, the manganese is intermediate, placing the undiagnostic slag firmly within the continuum identified so far. Furthermore, it maintains amounts of barium and strontium which are identical to those of the other slag types from Swart Village.

Ore

Samples of ore that were analysed revealed that a high grade ore was most likely exploited at Swart Village. Mineralogically, the ore was dominated by iron oxide with little amounts of gangue material. This microscopic observation was also reflected in the chemistry with the samples containing close to 80 wt% average FeO. The ore samples were also rich in manganese which was close to 10 wt% on average showing the possible link between the slag and the ore at the site. Two samples of local rocks from Trench 2 were very poor in iron, about 13 wt% on average (see appendix 2). However, they had an average manganese content of close to 8 wt% (average). This indicates that the ores were obtained from an area with a similar geological make up to that at the site. Overall, the low amounts of impurities in the ore likely used at

Swart Village suggest that the fuel ash and the technical ceramics may have played an important role in the slagging process.

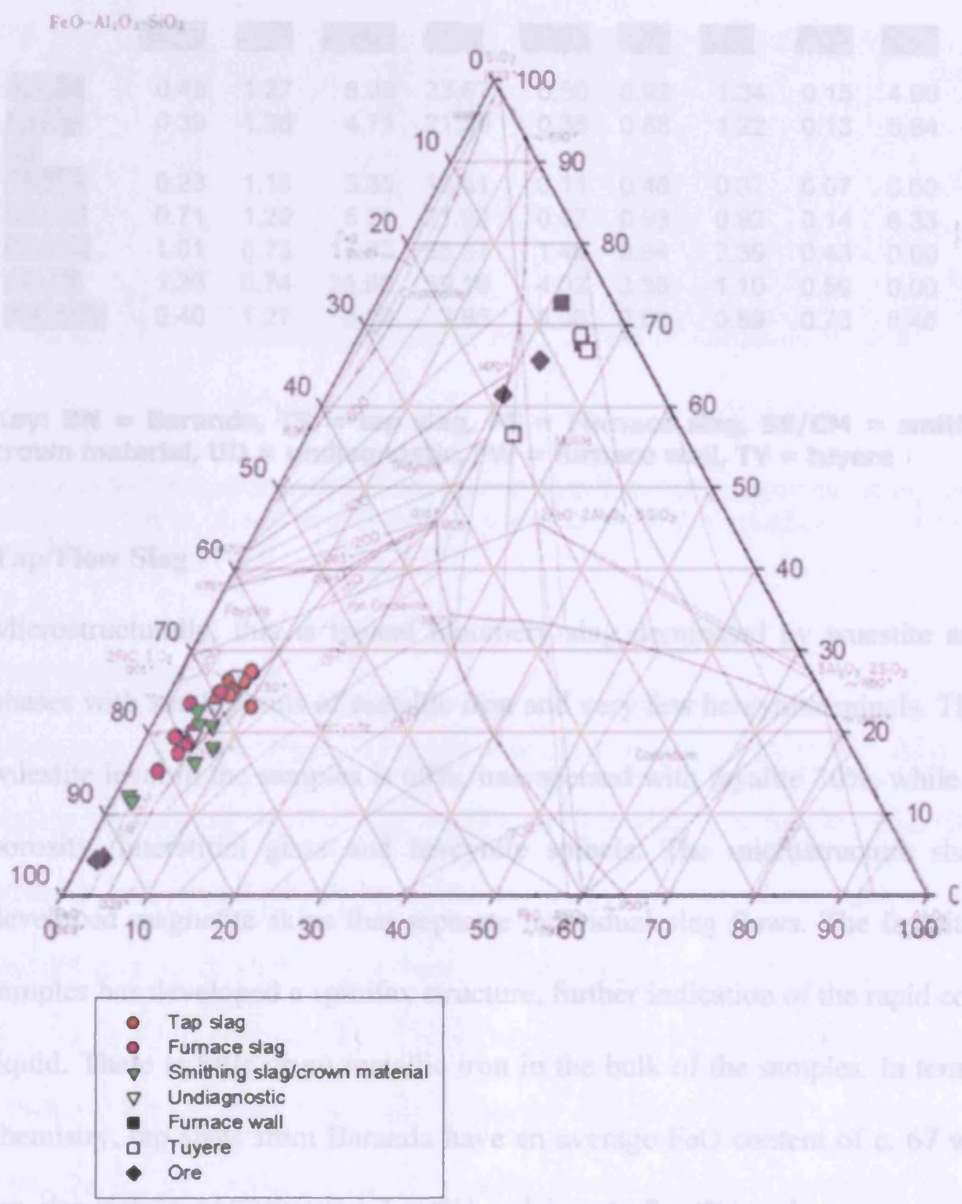
Technical ceramics

When viewed under the microscope, the tuyeres from Swart Village had large and small angular quartz grains which looked like carefully added tempering material in an ordinary ceramic matrix. Samples were also taken from domestic and architectural ceramics in order to evaluate if there was a conscious selection of clays for different activities at the site. Domestic pottery had inclusions of magnetite which could have come from sand being used as tempering material. The mineralogy of the pole impressed *dhaka* shows that it was from the ordinary clays with the quartz grains depicting their original rounded structure which was distinct from the crushed ones in the tuyeres.

Chemically, the technical ceramics from Swart Village are rich in alumina and silica as in most clay. The clay is very low in manganese, calcium and potassium suggesting that the enrichment of these elements in the slag may be contributions from the ore or fuel ash. The separation, based on mineral temper contents, in the technical ceramics from Swart Village is not reflected in their chemical composition. Neglecting the first of the three tuyere analyses, which is contaminated by a significant slag component as evidenced by the very high iron oxide and lime level, there is hardly any difference in the composition of tuyeres and furnace wall samples. When compared with clays from domestic pottery, the major difference appears to be the high level of FeO (15 wt%) in the local pottery as compared to the metallurgical ceramics. This is plausible in view of the fact that mineralogical analyses revealed grains of magnetite within the clay matrix in domestic pottery. This further supports the use of different tempering materials (quartz in tuyeres and magnetite sand in pottery). Magnetite would have strongly reduced the refractory properties of the clay (iron oxides are fluxes for silica), while the quartz improves them.

The iron working remains from the two sites were plotted on ternary diagrams to estimate the melting temperatures and the stages represented by the different suites of materials in the production process. These ternary diagrams are limited in that they show an ideal situation based on pure three-component systems and thus only approximate reality. However, combining manganese oxide with iron oxide and using the $FeO\text{-}Al_2O_3\text{-}SiO_2$ diagram accounts for well over 90 wt% of the constituent components, and makes the temperature estimates relatively reliable. As in most cases, the data plots neatly in the eutectic trough between wuestite, fayalite and hercynite, with the crown and furnace slag samples falling towards the wuestite-rich corner. Only a few samples plot outside this field, towards the cordierite composition. This is in close agreement with the observed dominance of wuestite in almost all samples and indicates a rather limited contribution of the ceramic material to the slag-forming processes in the smelt (Veldhuijzen and Rehren 2005). The tap slag stands out clearly for its low iron oxide content while the smithing slag and furnace slag grade into each other. These chemical differences to a large extent confirm the morphologies of various slag types. Some samples of crown material reach up to 85 wt FeO%.

Figure 46 **Ternary diagram from Swart Village**



Baranda

Table 13 shows average XRF results per materials from Baranda. See Appendix for all the results.

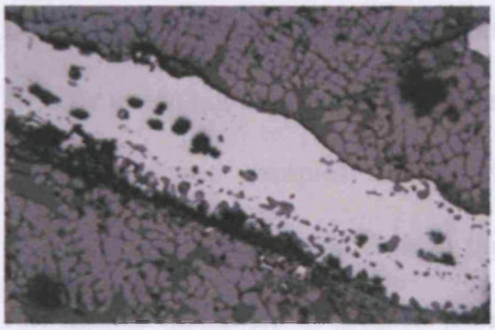
	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
BN TS	0.49	1.27	6.39	23.67	0.50	0.92	1.34	0.15	4.90	67.10	106.80
BN FS	0.39	1.36	4.71	21.39	0.36	0.88	1.22	0.13	5.84	74.53	110.84
BN SS/CM	0.23	1.15	3.35	13.41	0.11	0.46	0.37	0.07	6.60	87.15	112.92
BN UD	0.71	1.29	6.71	21.93	0.67	0.93	0.92	0.14	6.33	63.17	102.84
BN FW	1.01	0.73	17.73	65.67	1.40	3.64	2.39	0.43	0.00	3.49	96.47
BN TY	1.36	0.74	21.90	59.16	4.02	3.35	1.10	0.59	0.00	3.17	95.39
BN ORE	0.40	1.27	3.00	3.85	0.06	0.06	0.89	0.73	8.45	76.70	97.32

Key: BN = Baranda, TS = tap slag, FS = Furnace slag, SS/CM = smithing slag/ crown material, UD = undiagnostic, FW = furnace wall, TY = tuyere

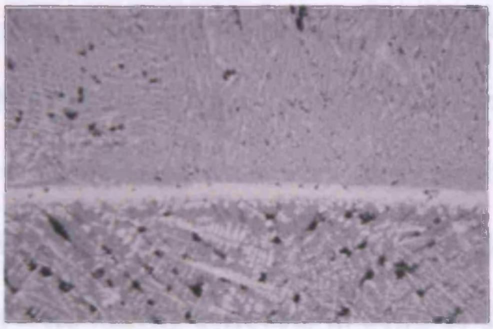
Tap/Flow Slag

Microstructurally, this is typical bloomery slag dominated by wuestite and silicate phases with small grains of metallic iron and very few hercynite spinels. The average wuestite level in the samples is 60%, interspersed with fayalite 30%, while the rest is porosity, interstitial glass and hercynite spinels. The microstructure shows well-developed magnetite skins that separate individual slag flows. The fayalite in some samples has developed a spinifex structure, further indication of the rapid cooling of a liquid. There is little or no metallic iron in the bulk of the samples. In terms of their chemistry, tap slags from Baranda have an average FeO content of c. 67 wt%. They are also rich in potassium (c. 1 wt%), calcium (c 2 wt%) and manganese (c. 5 wt% average) showing the influence of the ore and fuel ash in the furnace chemistry. The levels of trace elements such as barium, strontium and zirconium are variable but are generally low on the average suggesting that the technical ceramics may not have played a huge role in slag formation when compared to Swart Village for instance.

This is also supported by the fact that the level of barium is very high in the technical ceramics when compared to all the slag types (see Appendix).



(a) x50 mag



(b) x100 mag

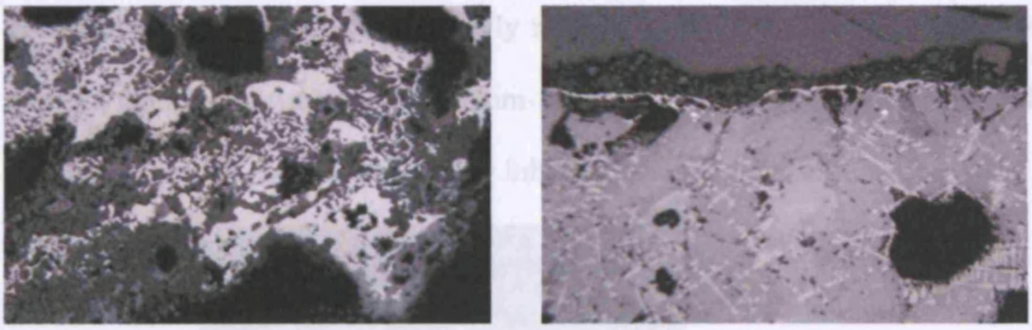
Figure 47 Individual slag flows separated by a band of magnetite, Baranda, (a). Trench 1, Layer, 3 and (b). Trench 3, Layer 1. Note the spinifex structure of the fayalite in sample (b)

Furnace Slag

Microscopically, this type of slag had wuestite between 60 and 65%, with the fayalitic phases representing the rest. The fayalite and wuestite were blocky indicating that the samples had cooled slowly and possibly in the furnace. Some minute particles of metallic iron were visible in some of the samples. Also, hercynite spinels (1%) could be observed in some samples. Chemically, the furnace slags from Baranda are very similar to the tap slags. The main difference appears in the FeO, which on average is close to 75 wt% in this case. The other chemical constituents such as magnesia, potash and calcium are similar tentatively indicating that the furnace slag and tap slag were part of the same technological process. Furnace slags have low amounts of trace elements such as barium, matching the observation made for the tap slags.

Smithing Slag and Crown Material

The possible smithing slag and crown material from Baranda had some points of similarity with that from Swart Village having a significant proportion of metallic iron. Metallic iron represented between 25% and 30% of the samples, the wuestite and fayalite are in equal proportions while the glassy phase occupies less than 5% in most of the analysed samples. However, the smithing slag was very rusty with a mineralogical composition akin to that of furnace slags. Some of the smithing slags had minute quantities of metallic iron which were heavily corroded. In terms of their chemical composition, these materials are conspicuous for their high FeO content with a combined average of close to 87 wt%. This also confirms the observation that smithing slags and crown material samples were heavy and rusty an indication of the metallic iron they contained. However, the smithing slags and crown material have lower levels of potash and calcium and are more related to the undiagnostic slags than to the tap and furnace slags. The significance of this is difficult to judge though more research would show whether this variation was due to factors in operation in the furnaces or the use of different smelting recipes.



(a) x50 mag (b) x200 mag

Figure 48 Photomicrographs of crown material from Baranda showing metallic iron (bright white interspersed with wuestite and fayalite in (a), (Trench 1 Layer 3) and (b) smithing slag Baranda Trench 1 Layer 3, showing wuestite in a fayalitic matrix.

Undiagnostic

Samples of undiagnostic slag were analysed mineralogically and chemically. While their phase composition is identical to that of furnaces slags, they differ in their chemistry. Undiagnostic slags have a much lower FeO content around 63 wt% and a slightly elevated amount of manganese. With the fluxing alkalis lower in this category of slag when compared to furnace and flow slags, it is more closely related to the smithing slags and crown material. However, the levels of trace elements are identical showing that the slags were produced using more or less the same raw materials.

Ore

In terms of elemental composition, ore samples from Baranda were very rich in FeO (almost 77 wt%). While the manganese is high, the potash and calcium are lower. The elevated levels of magnesia connect the ore to the slags. Mineralogically, iron oxide forms about 80 % of the sample, the rest being quartz particles and porosity. The microstructure of the ore is akin to that of partially reduced ore as there are some quantities of magnetite intermixed with lamellae of haematite. Clearly, this was a good ore which could be economically reduced to produce metallic iron. In view of the fact that the calcium and potassium are low in the ore, it becomes clear that the oxides detected in the slag were likely inherited from the fuel ash.

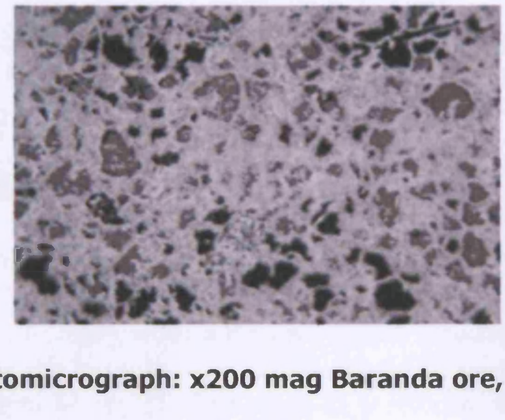
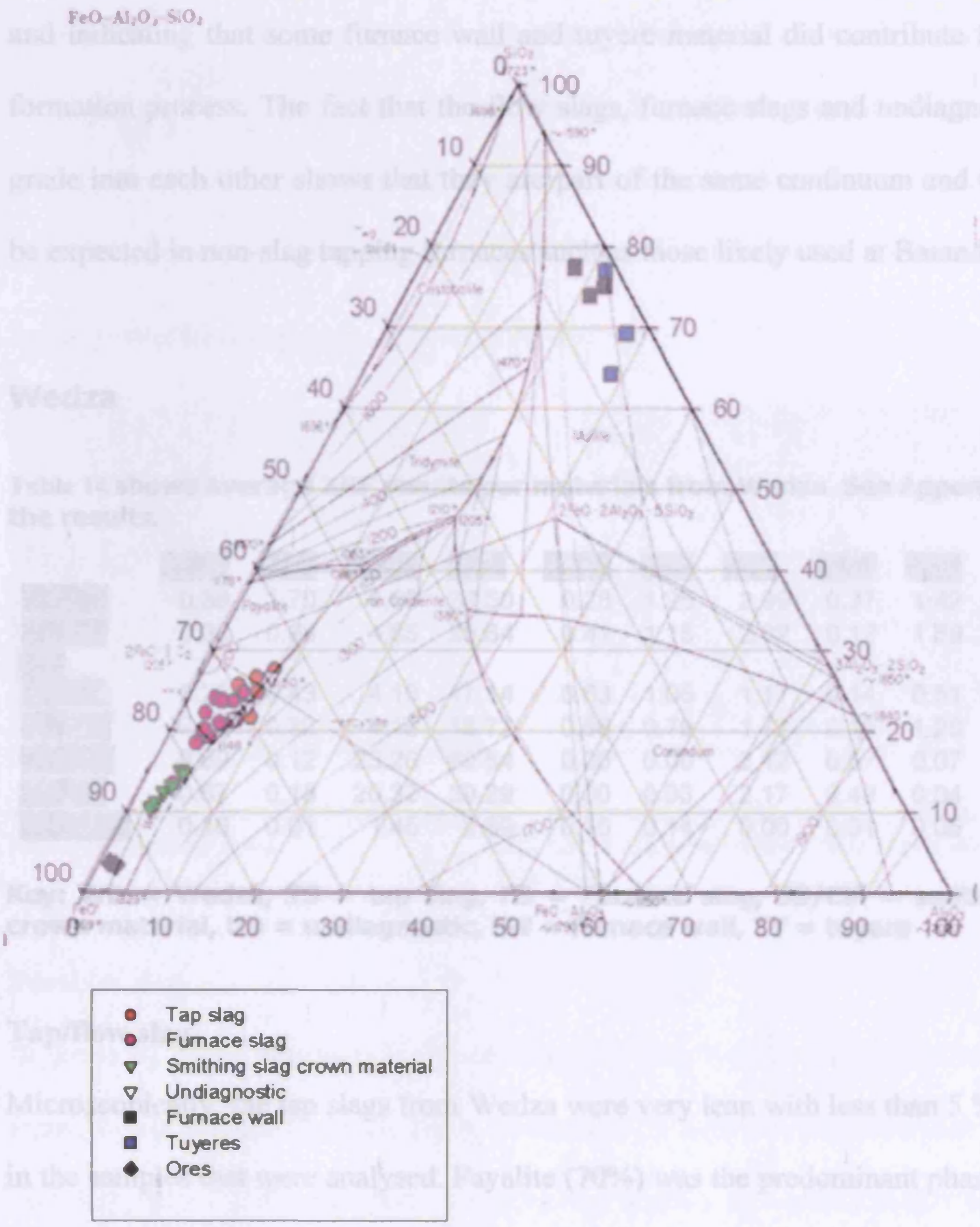


Figure 49 **Photomicrograph: x200 mag Baranda ore, Trench 3, Layer 2**

Technical ceramics

Mineralogically, the tuyeres and furnace fragments from Baranda had an almost identical microstructure with quartz inclusions in equal proportion with the ordinary clay matrix. The quartz grains do not appear to be crushed, which suggest that they were in the original clay. As with Swart Village, samples from local pottery and house floors were analysed with a view to compare their microstructure with that of metallurgical ceramics. The clays from both classes of artefacts exhibited a similar microstructure indicating a related source for both types of clay. Chemically, the clay used to make tuyeres and furnace walls at Baranda is relatively enriched in potassium (close to 4 wt% on average). However, the tuyere stands out for having a high phosphorous content (c. 4 wt%) and an alumina to silica ratio of 1:3 compared to the 1. 40 wt% phosphorous and 1: 4 ratio of alumina to silica in the furnace wall. The other differences in the concentrations of other elements such as magnesia and calcium indicates that the tuyeres are made from a different clay than the furnaces; the latter were of a not particularly refractory nature, while the tuyeres were manufactured from a high-alumina clay, probably necessary to enable the production of thin-walled (5 mm wall thickness) and heat-resistant tuyeres. The fact that the smelters managed to make very thin tuyeres is remarkable and demonstrates a high level of skill. The relative high level of alumina makes this a more refractory clay than that for Swart Village.

Figure 50 ternary diagram presentation of iron working remains from Baranda



When plotted on a ternary diagram, it became apparent that the slags from Baranda melted at temperatures between 1150 and 1200 C, typical for bloomery slags. Smithing slags and crown material from the two sites clearly stand out from the smelting slags by their high iron oxide content, approaching the ore composition. The smelting and smithing slags are much richer in alumina than can be explained by the ore composition alone. The tap slags in particular fall onto a line extending from the ore to the ceramic composition, going directly through the low melting eutectic trough and indicating that some furnace wall and tuyere material did contribute to the slag formation process. The fact that the flow slags, furnace slags and undiagnostic slags grade into each other shows that they are part of the same continuum and this would be expected in non-slag tapping furnaces such as those likely used at Baranda.

Wedza

Table 14 shows average XRF results per materials from Wedza. See Appendix for all the results.

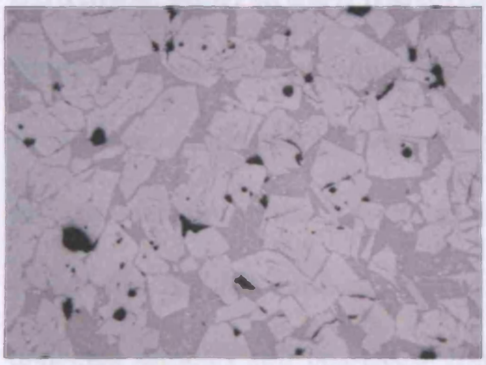
	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
WD TS	0.38	1.70	4.90	31.60	0.28	1.25	2.99	0.37	1.42	58.12	102.78
WD FS	0.32	0.98	4.85	25.64	0.41	1.15	2.82	0.12	1.59	66.56	104.44
WD SS/CM	0.23	0.43	4.10	17.14	0.63	1.06	1.17	0.14	0.51	81.45	106.87
WD UD	0.28	0.32	4.18	18.72	0.56	0.79	1.72	0.15	1.20	79.18	107.07
WD FW	0.69	0.12	23.26	60.54	0.00	0.00	2.12	0.57	0.07	7.34	94.72
WD TY	0.67	0.15	20.32	59.29	0.00	0.03	2.17	0.49	0.04	6.48	89.64
WD ORE	0.10	0.01	1.45	2.89	0.15	0.14	0.00	0.01	0.05	84.52	89.31

Key: WD = Wedza, TS = tap slag, FS = Furnace slag, SS/CM = smithing slag/ crown material, UD = undiagnostic, FW = furnace wall, TY = tuyere

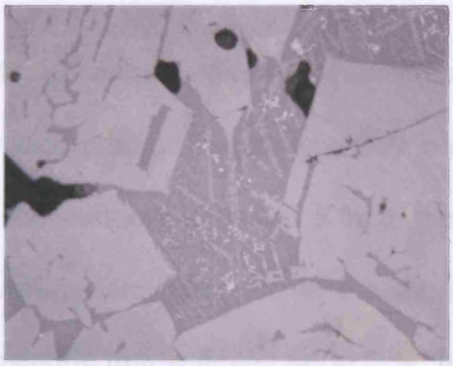
Tap/flow slag

Microscopically, the tap slags from Wedza were very lean with less than 5 % wuestite in the samples that were analysed. Fayalite (70%) was the predominant phase together with interstitial glass (15%). The samples analysed exhibited intermediate oxidation layers consistent with flow slag. Mineralogically, a sizeable number of samples had a spinifex structure showing that the slag was fully liquid and rapidly cooled. In some samples, magnetite spinels (2%) were intergrown with interstitial glass. Such magnetite spinels were visibly developing into wuestite. Minute quantities of metallic iron (1%) and hercynite spinels (5%) were also visible in a tiny fraction of the analysed flow slags. Chemically, the tap slags from Wedza stand out for being very lean in FeO which is around 58 wt% on the average. This is indicative of a very efficient slag – metal separation. The slag has got elevated levels of fluxing alkali and earth alkali metal oxides. The calcium possibly indicates the use of a high fuel to ore ratio by the smelters and or a higher blowing rate. Noteworthy but as yet unexplained is the low amount of manganese which is close to 1. 5 wt% on the average.

Figure 51 Photomicrographs of Wedza flow slag



a). Photomicrograph of flow slag from Wedza 5x mag.



b). photomicrograph showing blocky fayalite and second generation wuestite and spinels 20x mag.

Furnace slag

In terms of its microstructure furnace slag exhibits typical phases of the flow slag from Wedza discussed above, being dominated by fayalite and interstitial glass with very little wuestite. The fayalite is blocky and angular in a glassy matrix though it is difficult to see the grain boundaries of the fayalite in samples such as Wedza 3 and Wedza 5. This indicates that the slag cooled slowly and possibly inside the furnace. The fayalite is approximately 60% with wuestite being 30% and glassy matrix, porosity and hercynite taking up the rest. The abundance of fayalite represents efficient reduction and the significance of this will be discussed below. The slag has got some minute (1%) quantities of leucitic inclusions. Chemically, the furnace slag retain the silica to alumina ratio of the tap slags; the main distinguishing feature being the higher FeO content which is on the average c. 66 wt%. The furnace slags also contain elevated levels of calcium and potassium the typical fuel ash oxides. Besides the variance in the FeO composition, all the other elements are identical to those found in the tap slags. The trace elements such as barium, strontium and zirconium are also found in elevated quantities which are identical to those in the tap slags.

Smithing slag/Crown material

Samples of possible smithing slag were studied mineralogically. Microstructurally, these were dominated by wuestite and fayalitic phases. In addition, they contained leucitic inclusions which averaged 10% in the smithing slags and 5 % in the crown material. Very few amounts of crown material were recovered at the site but the analysed samples still possessed grains of metallic iron reaching up to 5 %. In terms of chemical composition, FeO stands out as the element with the highest concentration of c. 82 wt% on the average. The silica to alumina ratio is on the average 5:1 which is close to that found in the smelting slags. While the potassium levels are the same as those of the smelting slags, the calcium content is lower in the smithing slag. Overall, the trace and major oxide composition suggests that these materials are geochemically related.

Undiagnostic

The undiagnostic slags are wuestite rich with fayalite in a glassy matrix. They closely resemble smithing slags and crown material from the site in terms of their mineralogy. Chemically, this relationship is reflected by the high FeO content of almost 80 wt% which is well above that found in smelting slags. Undiagnostic slags are lower in potassium and calcium when compared to flow and furnace slags. However they contain manganese content close to 1 wt% which is more or less the same as in the tap and furnace slag.

Technical ceramics

The major phases in the samples were the clay matrix (70%) containing inclusions such as feldspars and quartz grains (30%). The feldspars have got a low melting point which promotes the early formation of a free running slag. Noteworthy is the appearance of quartz grains which are shattered and not particularly angular as deliberately added temper would look like. The microstructure of the clays used to make the tuyeres is indistinguishable from that of the furnace superstructure. In addition, the vitrified lining of the technical ceramics is bloated and glassy with some slagged parts consisting of wuestite and fayalitic phases. In terms of chemical composition, silica to alumina ratio in both the tuyeres and furnace wall is 3:1. With an almost identical level of magnesium, potassium and calcium, it seems that the clay for making tuyeres and the furnace wall was sourced from the same area.

Ore

Samples of partially reduced ore from the smelting area and raw "ore" from the iron mine were studied using reflected light microscopy. The partially reduced ore is predominantly haematite dominated by iron oxide which is about 80%. The quartz grains and other impurities make up the remaining 20%. This high grade ore would have given a high yield. The raw ore from the mine had different compositions of iron oxide ranging from 20% to 40% and inversely contained much of the gangue minerals. The chemical analysis of the two ores was done to evaluate if there are any hereditary relationships between any of them and the slag retrieved from the site as would be visible for example by similar elemental signatures. The analysed ore samples are distinguished by their very high FeO content which is on the average close to 85 wt%. Inversely, they are very lean in alumina and silica. In contrast, one ore sample from the mines is very rich in silica and alumina and lean in FeO. The ore from the smelting site is "pure" with little impurities such as manganese, potash and barium indicating that the ore, fuel ash and the technical ceramics may have played an important role in the slagging process.

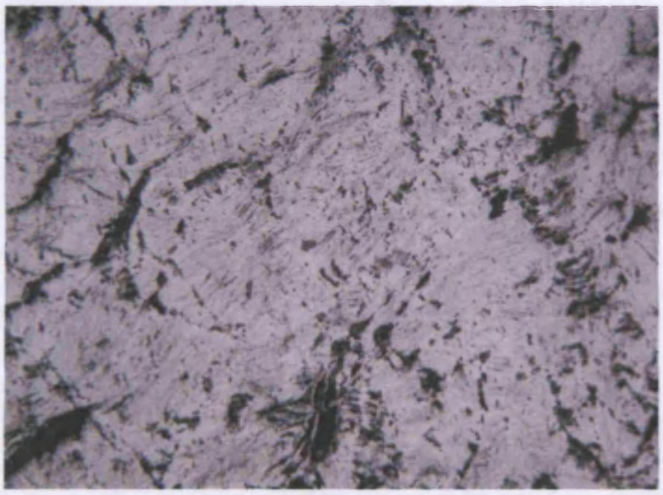


Figure 52 Photomicrograph of a nodule of haematite from the iron smelting site 200x mag.

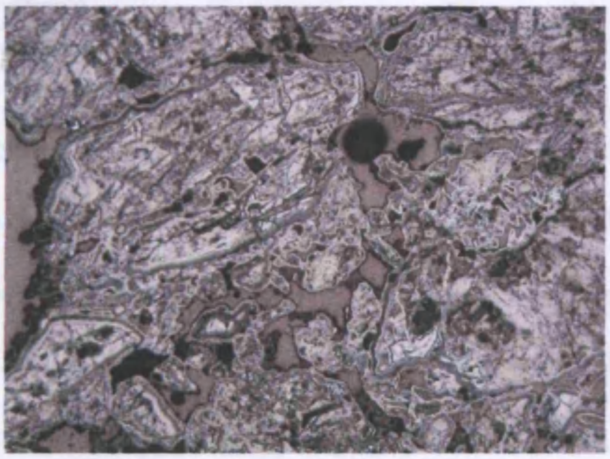
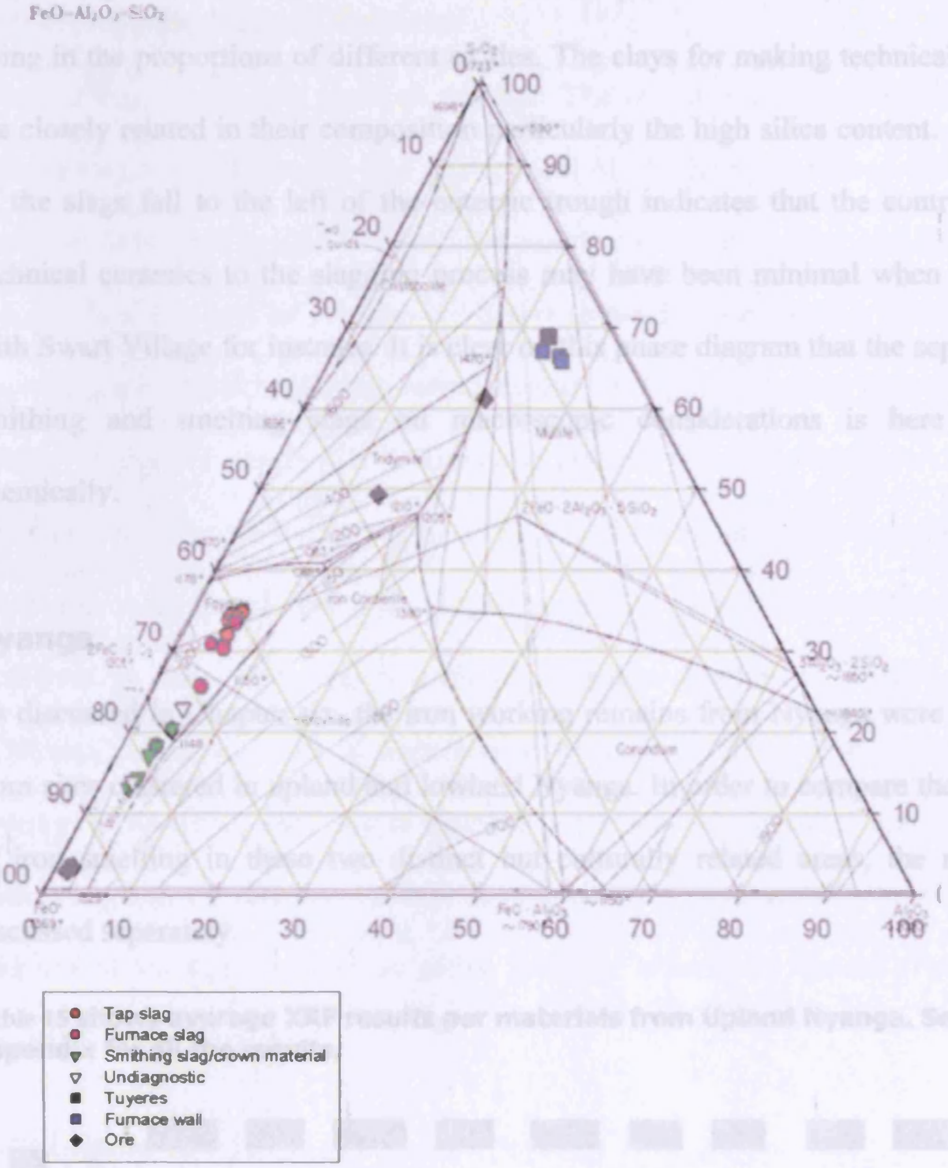


Figure 53 Photomicrograph of ore from the smelting site showing haematite which is consolidated by iron hydroxide x50. mag.

Figure 54 Ternary diagram presentation of analysed samples from Wedza



A closer look at the diagram shows that most of the slags fall within the low melting temperature zone of between 1100 degrees Celsius and 1200 degrees Celsius. The amount of residual iron in the slags and where they fall on the diagram also helps to distinguish between smelting slags and smithing ones. While most of the smelting slags fall between the 60 percent and 70 percent FeO mark, the smithing slag reach up to 85 percent. The smelting slag (tap and furnace) is clustered in the fayalite region and clearly grade into each other showing that it is part of a stepped continuum. The undiagnostic slags fall in the same region as the smithing slags. The slags have got a relationship with the ore in terms of chemical composition, the only notable difference being in the proportions of different oxides. The clays for making technical ceramics are closely related in their composition particularly the high silica content. That most of the slags fall to the left of the eutectic trough indicates that the contribution of technical ceramics to the slagging process may have been minimal when compared with Swart Village for instance. It is clear on this phase diagram that the separation of smithing and smelting slags on macroscopic considerations is here reflected chemically.

Nyanga

As discussed in Chapter six, the iron working remains from Nyanga were recovered from sites clustered in upland and lowland Nyanga. In order to compare the practices of iron smelting in these two distinct but culturally related areas, the results are discussed separately.

Table 15 **shows average XRF results per materials from Upland Nyanga. See Appendix for all the results.**

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	MnO	FeO	Total
UP SS/CM	0.41	0.40	7.76	14.94	0.52	1.43	0.61	0.33	0.56	84.85	111.81
UP UD	0.16	0.08	6.92	15.75	0.46	1.53	1.14	0.25	0.47	78.61	105.38
UP ORE	0.15	0.04	4.00	6.38	0.06	0.08	0.03	0.06	0.03	73.56	84.36
UP FW	0.25	0.52	23.87	62.70	0.07	3.32	1.93	0.27	0.03	3.95	96.90
NF TS	0.44	0.63	6.07	19.04	0.72	1.63	1.52	0.24	0.13	74.69	106.01
NF FS	0.46	0.59	6.82	17.22	0.93	1.14	1.28	0.22	0.14	77.35	106.14
NF SS/CM	0.52	0.65	6.70	15.20	0.70	1.57	0.93	0.21	0.13	82.43	108.97
NF UD	0.47	0.66	7.82	15.80	0.51	1.17	1.26	0.23	0.13	77.62	105.68
DM FS	0.34	0.51	6.13	15.77	0.44	1.73	0.91	0.21	0.35	78.31	104.69
DM SS/CM	0.30	0.36	6.45	15.47	0.43	1.82	1.17	0.19	0.25	81.46	107.89
DM UD	0.22	0.42	7.41	16.81	1.01	2.08	1.09	0.14	0.16	79.14	108.92

Key: DM = Demera, NF = Nyamuzihwa Falls, UP = Upper Pungwe, TS = tap slag, FS = Furnace slag, SS/CM = smithing slag/ crown material, UD = undiagnostic, FW = furnace wall

Upper Pungwe

Smithing slag/crown material

No smelting slags were found at the site. The crown material from Upper Pungwe had sizeable amounts of metallic iron (30%) some of which had coalesced while some particles stood as individual grains. A significant number of samples were heavily corroded on the edges. This category of remains contained about 25% dendritic wuestite which in some instances was transforming into metallic iron. The fayalite forming 20% of the samples was blocky in a glassy matrix (5%). This crown material from Upper Pungwe is also notable for its high hercynite content averaging 15%. The charcoal and organic materials embedded in the samples are also visible in the materials. As with the crown material from the other areas analysed so far, this category posses a sizeable quantity of leucitic inclusions (5%). Chemically, this material is characterised by a high FeO concentration which is on the average c. 85 wt%). The ratio of alumina to silica in this group of materials is almost 1:2, which explains the high amount of hercynite visible mineralogically. So far, the material has the lowest levels of manganese which probably reflects on the use of an ore which was deficient in the element.

Undiagnostic

The undiagnostic slag from Upper Pungwe is mineralogically and chemically related to the smithing slag and crown material. It has a lower FeO content of c. 79 wt%, however. Other than this, the other oxides and trace elements seem to be identical indicating that the undiagnostic slag was probably part of the same technological process as the crown material.

Ore

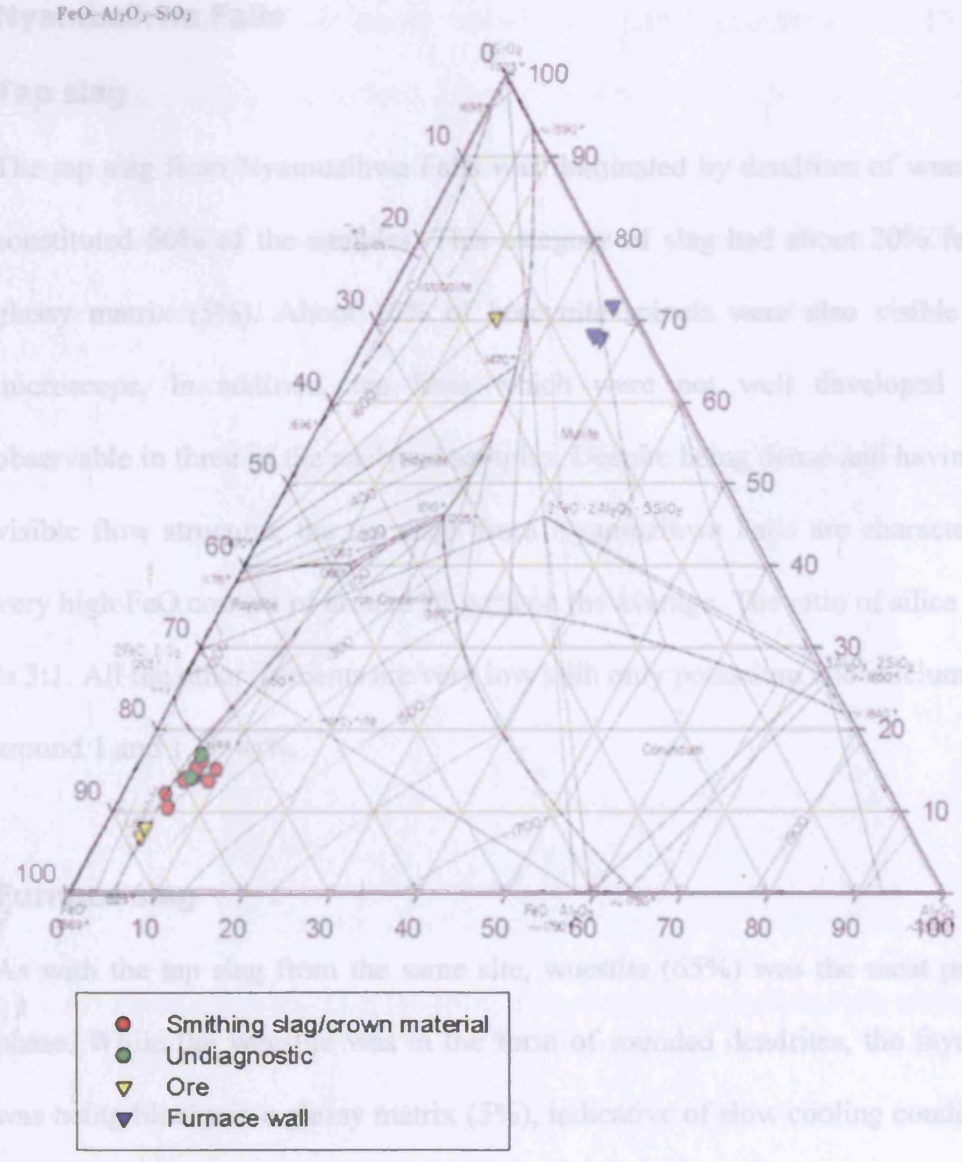
Two pieces of possible ore were recovered in association with the smithing slag and crown material at Upper Pungwe. Sample A had about 80% iron hydroxide in addition to about 10% quartz grains and 10% natural clay inclusions. In addition, small particles of bright yellow minerals were visible, possibly copper-iron sulphides. Sample B is principally different from Sample A or the real ore containing the opposite ratio of ore mineral to quartz sand. It is highly plausible that the material for sample B was used for other purposes such as tempering clays as they have no economically extractable iron (see below on technical ceramics).

In terms of chemical constituents, the ore sample A was very rich in iron oxide with an average FeO content of close to 75 wt% thus making it qualify as a good ore. The concentrations of silica and alumina are also low in the ratio of 3:2. Interestingly, the slag material has got about one half of a percent manganese oxide which is not reflected in the ore. The material similar to that analysed as sample B using reflected light microscopy was also studied chemically. While the material is very poor in iron, it has got enriched levels of silica (c. 67 wt%). This indicates that the material does not qualify as ore.

Technical ceramics

In terms of its microscopy, the furnace wall was dominated by the ordinary clay matrix with quartz grains constituting about one quarter of the samples. The quartz grains were shattered due to exposure to heat. They do not look like deliberately added tempering material. Interestingly though, the furnace wall comprises quartz rich rock inclusions which are also visible macroscopically. The rock material is identical to the material analysed as “ore” sample B which had small amounts of iron oxide. Clearly, there is a high possibility that this material was deliberately added as tempering material as it is different from quartz in the ordinary clay matrix. Chemically, the furnace wall was characterised by a high level of silica relative to alumina (3:1). The clays have got lower levels of elements such as potassium and calcium than the slag showing that those could have been derived from a different source such as fuel ash.

Figure 55 Ternary diagram presentation of slags from Upper Pungwe



Both the smithing slag/crown material and undiagnostic slag from Upper Pungwe falls within the wuestite rich zone which is approaching the composition of the ore. The slags melted at high temperatures as some samples plot onto the 1 300 degrees Celsius temperature line. The alumina in the samples is also fairly high reflecting the high amount of hercynite detected mineralogically. The furnace wall material is also rich in silica and alumina. Overall, the high amount of FeO in the materials confirms that macroscopic classification of them being associated with smithing rather than smelting.

Nyamuzihwa Falls

Tap slag

The tap slag from Nyamuzihwa Falls was dominated by dendrites of wuestite which constituted 60% of the samples. This category of slag had about 20% fayalite in a glassy matrix (5%). About 10% of hercynite spinels were also visible under the microscope. In addition, tap lines which were not well developed were also observable in three of the analysed samples. Despite being dense and having a clearly visible flow structure, the tap slags from Nyamuzihwa Falls are characterised by a very high FeO content of around 75 wt% on the average. The ratio of silica to alumina is 3:1. All the other elements are very low with only potassium and calcium averaging around 1 and 1. 5 wt%.

Furnace slag

As with the tap slag from the same site, wuestite (65%) was the most predominant phase. While the wuestite was in the form of rounded dendrites, the fayalite (20%) was being blocky in a glassy matrix (5%), indicative of slow cooling conditions. Also visible in the microstructure of the samples are angular chunks of hercynite spinels. The furnace slag from Nyamuzihwa Falls is fairly porous with some charcoal inclusions. Chemically, the level of FeO is slightly higher than that found in the tap slag which is around 77 wt%. The furnace slag is also rich in calcium, phosphorous and potassium, the typical fuel ash elements.

Smithing slag/crown material

Mineralogically, this slag was identical to smelting slags. The major difference was in the levels of leucitic inclusions (10%) in smithing slag compared to the 2% in the furnace slag. Some of the crown material had small amounts of metallic iron with some grains coagulating to form larger pieces of metal. The suites of iron working remains classified here as smithing slag/crown material could be transitional between crown material and furnace slag. This microscopic observation was well matched by the elevated amounts of FeO (c. 82 wt%) revealed chemically. In the absence of furnace slag from the site, it is possible that the material is associated with smithing.

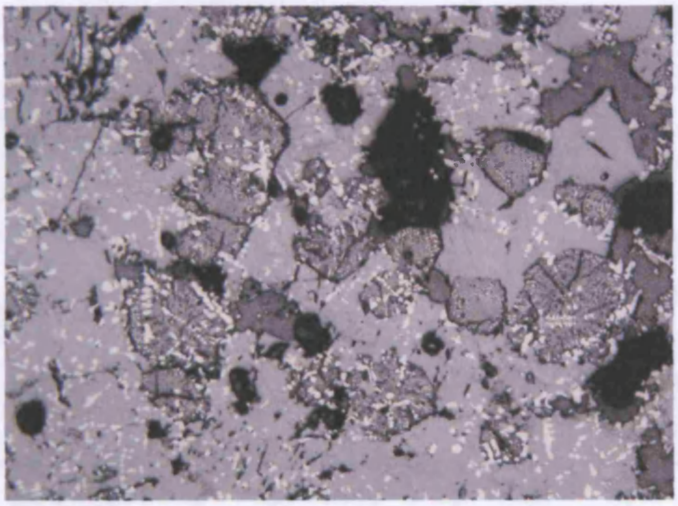


Figure 56 Photomicrograph of smithing slag from Nyamuzihwa Falls showing the abundance of leucitic inclusions x 100 mag.

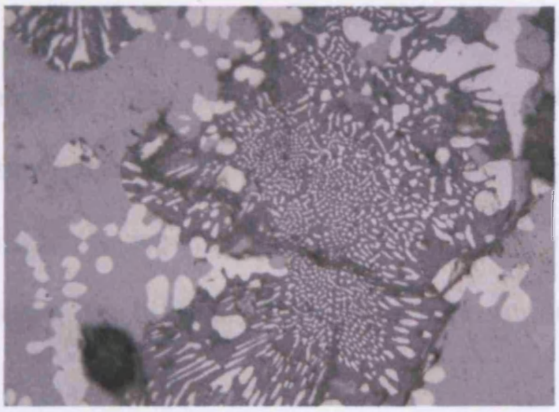
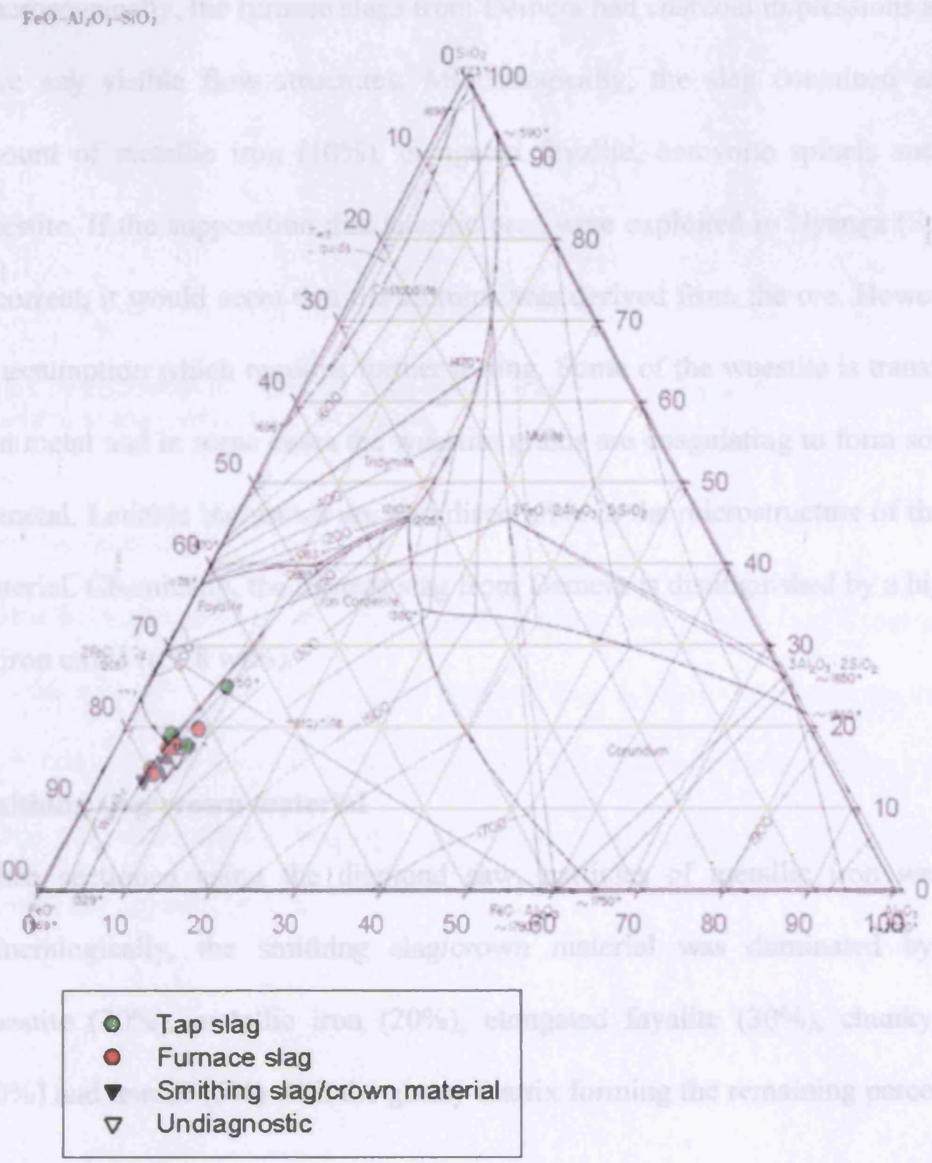


Figure 57 Photomicrograph of smithing slag from Nyamuzihwa Falls showing the abundance of leucitic inclusions x 500 mag.

Figure 58 Phase diagram of slag from Nyamuzihwa Falls.



Clearly, the samples from this site are clustered in the wuestite dominated zone, reflecting the iron rich nature of the slags. However, all but one sample of tap slag are grouped in one area showing that the different suites of slags grade into each other and that it is more difficult to separate them chemically. In the absence of ore and technical ceramic samples, it is difficult to estimate their contributions to the furnace chemistry.

Demera

Furnace slag

Macroscopically, the furnace slags from Demera had charcoal impressions and did not have any visible flow structures. Mineralogically, the slag contained an elevated amount of metallic iron (10%), elongated fayalite, hercynite spinels and dendritic wuestite. If the supposition that lateritic ores were exploited in Nyanga (Soper 2002) is correct, it would seem that the alumina was derived from the ore. However, this is an assumption which requires further testing. Some of the wuestite is transforming to iron metal and in some cases the wuestite grains are coagulating to form solid chunks of metal. Leucitic inclusions are also discernible in the microstructure of the analysed material. Chemically, the furnace slag from Demera is distinguished by a high amount of iron oxide (c. 78 wt%).

Smithing slag/crown material

When sectioned using the diamond saw, particles of metallic iron were visible. Mineralogically, the smithing slag/crown material was dominated by dendritic wuestite (30%), metallic iron (20%), elongated fayalite (30%), chunky hercynite (10%) and leucite (5%) with the glassy matrix forming the remaining percentage. The samples were corroded on the outer edges and in some cases the rust had eaten away the metallic iron in them. Chemically, the smithing slag/crown material was dominated by FeO with an average content of 80 wt%. The ratio of alumina to silica is 1:2 which corroborates the abundance of hercynite detected microscopically. Additionally, the analysed samples have got enriched levels of calcium and potassium which probably derived from fuel ash.

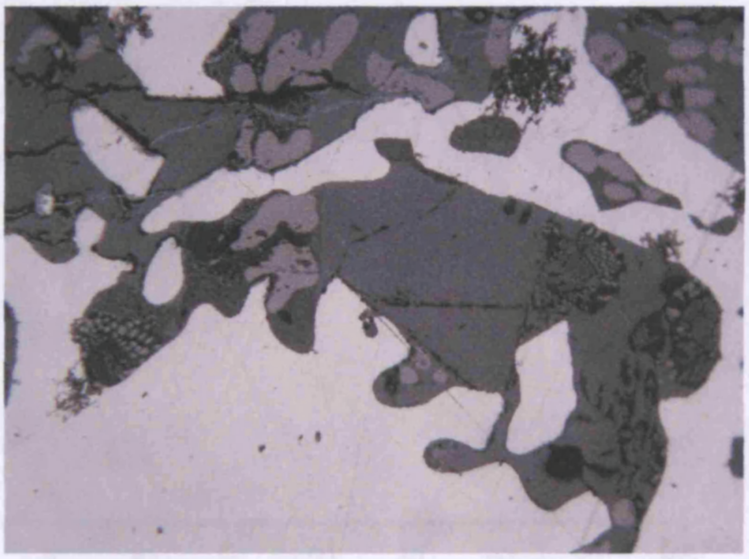
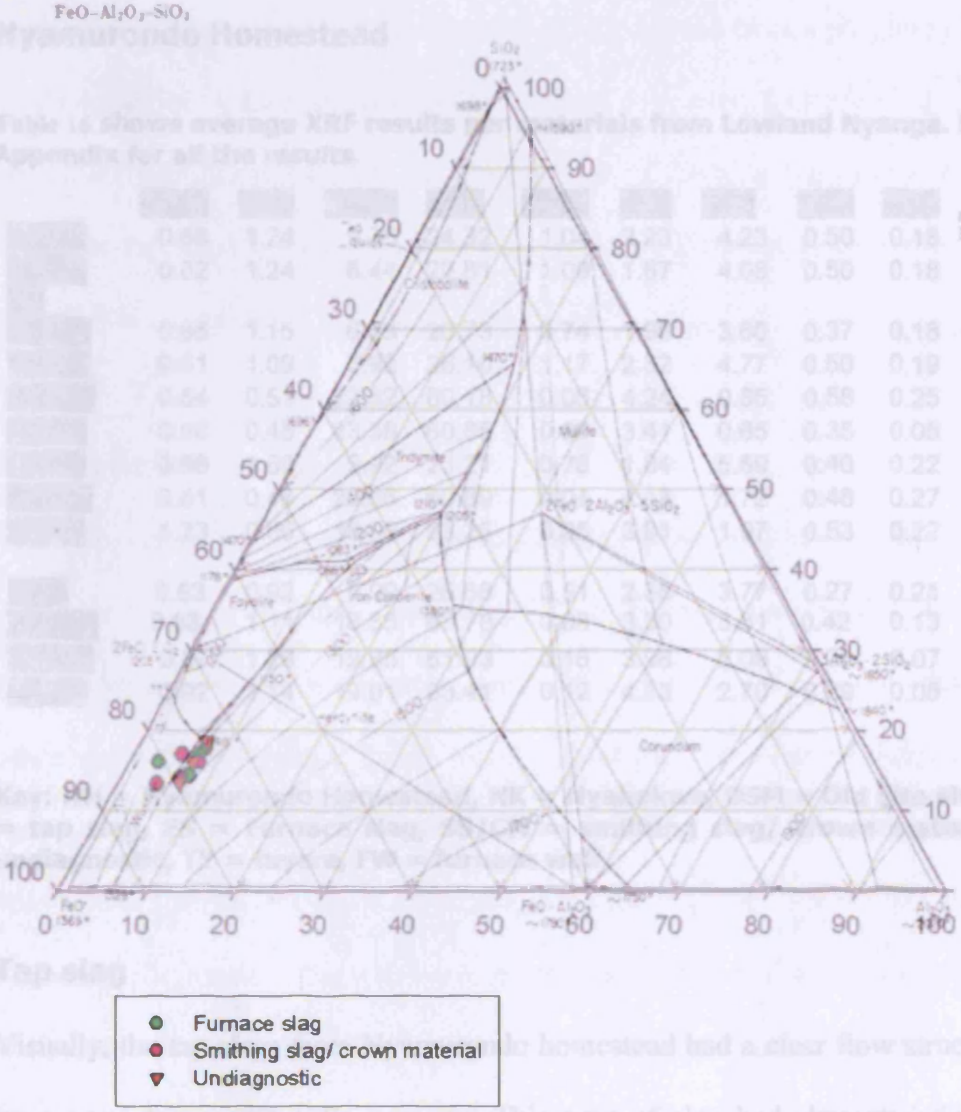


Figure 59 **Photomicrograph of crown material from Demera showing metallic iron, wustite, some corrosion x 500 mag.**

Undiagnostic

Chemically, the undiagnostic slag from Demera is rich in FeO. It still maintains the 1: 2 alumina to silica ratio of the other types of slag. It has more potassium and calcium when compared to furnace slags for instance. This material nicely grades into both the crown material/smithing slag and the furnace slag suggesting that all the suites of remains are closely related.

Figure 60 Ternary diagram presentation of slags from Demera



The slags from Demera are fairly homogenous and fall within the high wuestite region. This grouping together indicates that the material was part of the same continuum. The slag also contains elevated levels of alumina which are consistent with the hercynite observed microscopically. Overall, the high amount of FeO would link these materials more to smithing than smelting.

Nyamurondo Homestead

Table 16 shows average XRF results per materials from Lowland Nyanga. See Appendix for all the results.

	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
NH TS	0.66	1.24	9.76	24.32	1.04	2.23	4.23	0.50	0.18	65.41	109.58
NH FS	0.62	1.24	8.44	22.81	1.09	1.87	4.08	0.50	0.18	70.90	111.74
NH SS/CM	0.65	1.15	6.33	20.73	0.74	1.96	3.60	0.37	0.18	73.99	109.73
NH UD	0.81	1.09	8.93	26.10	1.17	2.32	4.77	0.50	0.19	69.71	115.58
NH FW	0.54	0.51	22.32	60.18	0.06	4.24	0.85	0.58	0.25	3.96	93.49
NH TY	0.98	0.45	23.38	60.85	0.02	3.41	0.65	0.35	0.05	5.30	95.45
NK FS	0.88	1.69	9.92	23.21	0.76	1.84	5.59	0.40	0.22	63.76	108.25
NK FW	0.61	0.46	20.66	60.89	0.04	4.13	1.72	0.48	0.27	3.83	93.05
NK TY	1.23	0.66	18.56	63.26	0.05	3.91	1.97	0.53	0.22	5.22	95.61
OSM	0.63	0.92	8.99	26.66	0.51	2.35	3.77	0.27	0.21	64.07	108.38
ZW FW	0.88	1.11	18.35	63.78	0.08	3.30	3.81	0.42	0.13	5.92	97.49
SN FW	0.87	1.29	19.85	61.93	0.16	3.98	2.09	0.30	0.07	4.74	95.26
SN TY	0.92	1.14	19.01	63.41	0.12	4.13	2.70	0.29	0.05	4.80	96.55

Key: NH = Nyamurondo Homestead, NK = Nyahokwe, OSM = Old Site Museum, TS = tap slag, FS = Furnace slag, SS/CM = smithing slag/ crown material, UD = undiagnostic, TY = tuyere, FW = furnace wall

Tap slag

Visually, the tap slags from Nyamurondo homestead had a clear flow structure. They were very dense with little porosity. This type of slag had characteristic oxidation layers that separate individual slag flows. Two samples, Nyamurondo 1 and 5, had developed a spinifex structure. Microstructurally, dendritic wuestite formed about 50% of the sample, the rest being fayalite (30%) in a glassy matrix (10%) and hercynite (10%). The elongated and skeletal nature of the fayalite further suggests that the slag cooled rapidly. The sand grains attached to the bottom of the slag were shattered due to exposure to the heat from the slag. In terms of elemental composition, this category of remains has got a relatively low FeO content (c. 65 wt%) which is lean when compared with similar artefact suites such as slags from Nyamuzihwa

Falls. The ratio alumina to silica is 1:2, which corresponds to the high level of hercynite in the materials. The slag was possibly derived from a phosphorous rich ore as shown by the raised amount of the element. However, fuel ash is also known to contribute significant amounts of phosphorous to the slag (Ige and Rehren 2003). Also, the tap slags from the site have got enriched levels of potassium and calcium typical fuel ash oxides.

Furnace slag

Wuestite was the predominant phase constituting about 60% of the analysed samples. This was followed by blocky fayalite (25%) in a glassy matrix (5%). In addition to being porous (2%), the material was hercynite rich (5%) which is consistent with the other slags from Nyanga. Some samples contained sizeable particles of partially reduced ore while others had small amounts of metallic iron. The ore particles clearly showed the transformation of ore to slag with most of the intermediate stages being visible. In the centre of the ore areas, the grain boundaries of magnetite changing into haematite were visible. The ore probably started as haematite and was slowly transforming into magnetite. In the areas with slag, dendritic wuestite predominated as in the other slags. Minute particles of metallic iron were also visible. The furnace slags are similar to the tap slags in their principal components. The only difference is in the high amount of FeO in the furnace slags which is about 70 wt% on the average. This has been elevated by the inclusions of metallic iron. The amounts of potassium and calcium are also high and identical to the tap slags. The ratio of alumina to silica is also 1:2, linking the tap slag and furnace slag.

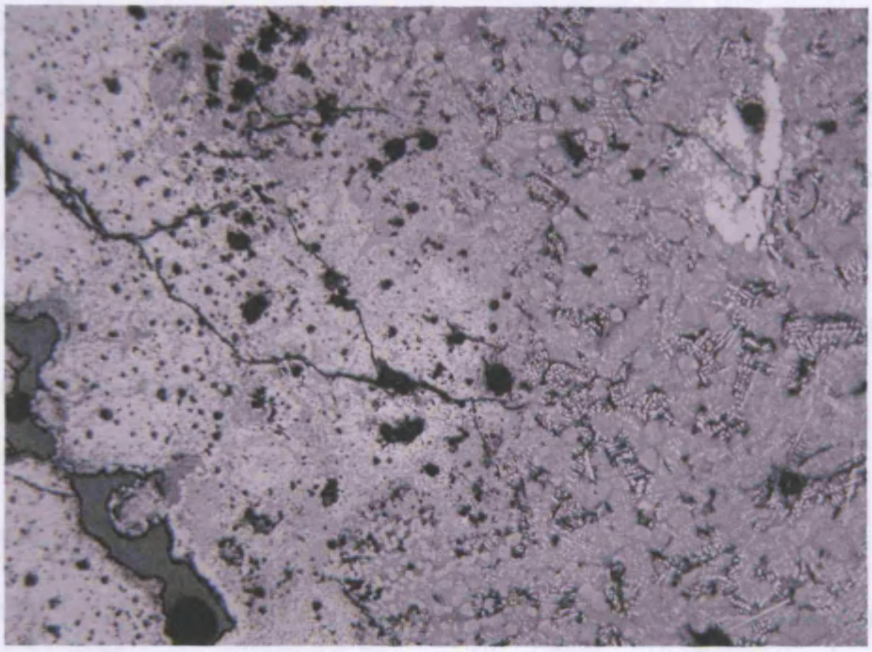


Figure 61 Photomicrograph showing the ore and wuestite dissolving into slag. x100 mag

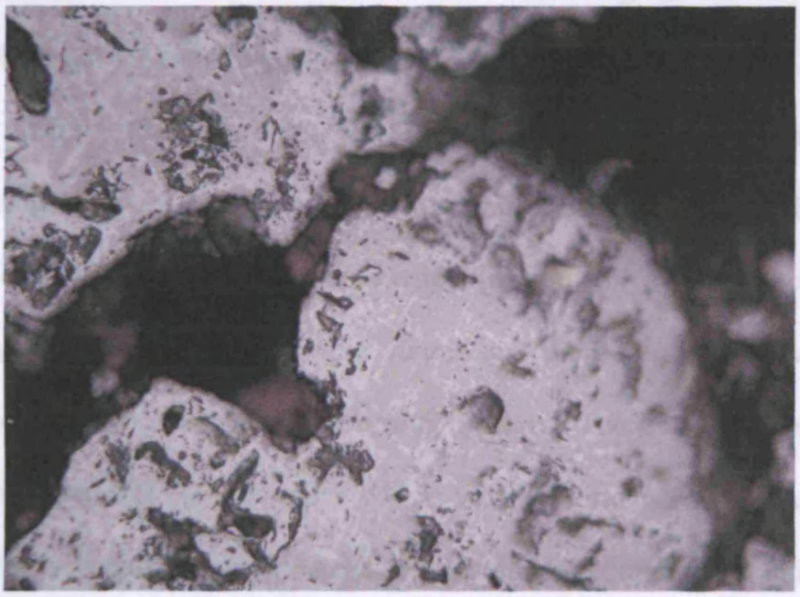


Figure 62 Photomicrograph showing haematite and magnetite (these ore particles are in the middle of a wustite dominated slag) x 500 mag. xp.

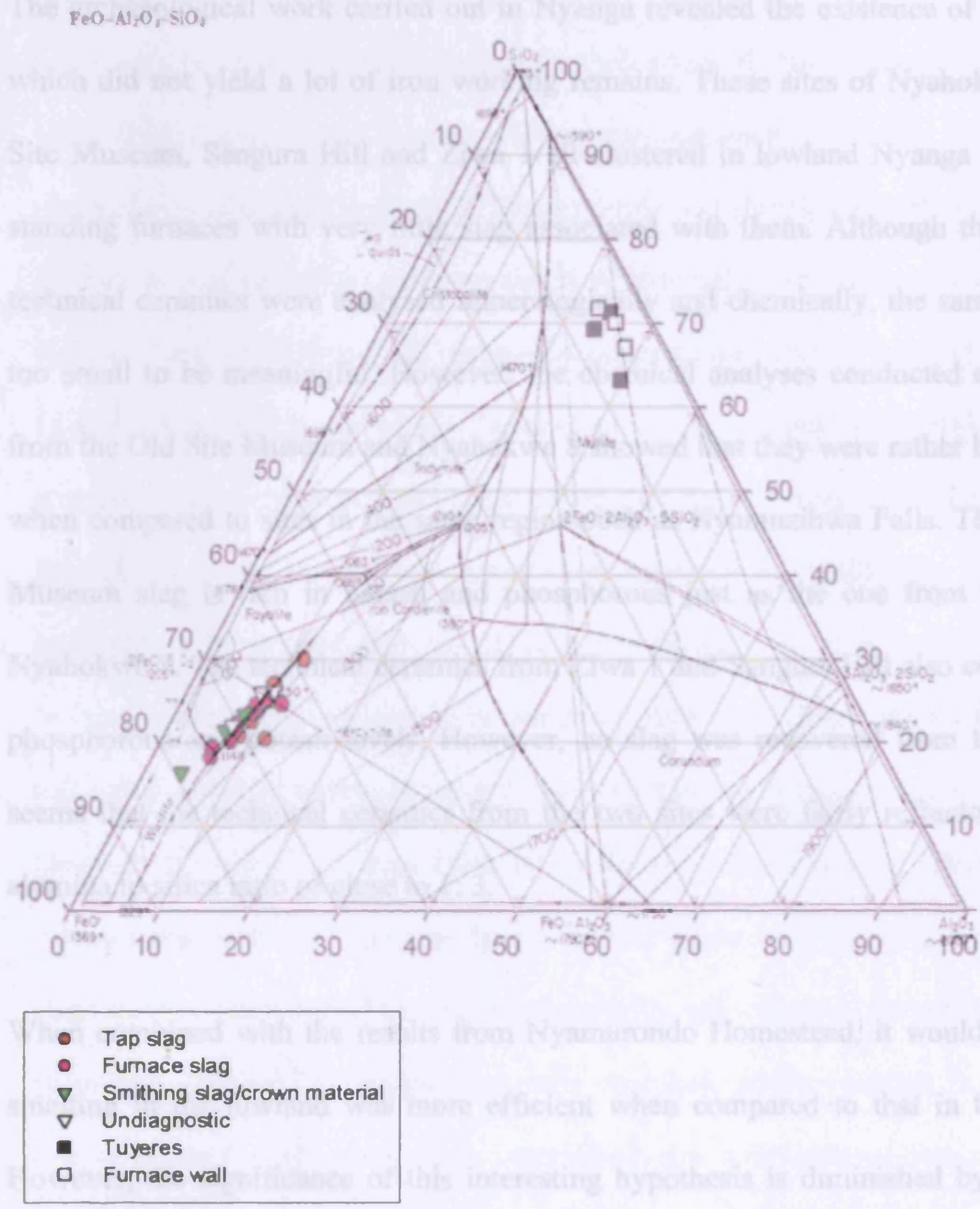
Smithing slag/Crown material

Very few samples of this material were found. Microstructurally, the smithing slags/crown materials were indistinguishable from similar materials from the other sites being dominated by dendritic wuestite (25%), elongated fayalite (35%), metallic iron (20%), porosity (10%), with hercynite and the glassy matrix being 5% each. However, the only distinguishing features seemed to be the low levels of leucite in these samples when compared to similar material from Demera and Upper Pungwe. Chemically, FeO dominated with an average of c. 73 wt%. The smithing slags are also rich in calcium and potassium and phosphorous indicating that they were part of the same series of materials with the smelting slags.

Technical ceramics

Noteworthy in this artefact category was the dominance of quartz inclusions and the glassy matrix which constituted about 80% of the bloated ceramic materials. On the other hand, hercynite spinels were about 15% the rest being the ordinary clay matrix. In all samples, a temperature gradient from the outside to inside is visible as the inside is heavily vitrified while near the outside the original porosity is still visible as irregular elongated pores while nearer the inside they are partly rounded from fusion and slag forming reactions. In the vitrified portions of the technical ceramics, individual grains of metallic iron were visible and these possibly derived from the reduction of iron oxide naturally occurring in clays. The technical ceramics were analysed chemically in the laboratory with a view to establish if similar clays were used to make tuyeres and furnace walls. The elemental composition and the ratio of alumina to silica is 1:3 in the tuyeres and 1:2 in the furnace wall. Thus the furnace wall seems to be more refractory than the tuyeres. However, both clays were good quality and lasted the duration of the smelt. The clay for tuyeres is also enriched in potassium probably from a granite background.

Figure 63 Ternary diagram plot of slag and technical ceramics from Nyamurondo Homestead



The slags from Nyamurondo Homestead are clustered in the same region between the fayalite and wustite troughs with a few outliers from tap slag and smithing slag. While it was possible to separate the different groups of slag on the basis of morphology, chemically it is difficult to do so. The technical ceramics grade into each other. However, one tuyere sample is low in silica compared to others.

Nyahokwe 8, Old Site Museum, Sangura Hill and Ziwa 1

The archaeological work carried out in Nyanga revealed the existence of some sites which did not yield a lot of iron working remains. These sites of Nyahokwe 8, Old Site Museum, Sangura Hill and Ziwa 1 all clustered in lowland Nyanga are mostly standing furnaces with very little slag associated with them. Although the slag and technical ceramics were analysed mineralogically and chemically, the sample size is too small to be meaningful. However, the chemical analyses conducted on the slag from the Old Site Museum and Nyahokwe 8 showed that they were rather lean in FeO when compared to sites in the same region such as Nyamuzihwa Falls. The Old Site Museum slag is rich in potash and phosphorous just as the one from the nearby Nyahokwe 8. The technical ceramics from Ziwa 1 and Sangura Hill also contain high phosphorous and potash levels. However, no slag was recovered from the sites. It seems that the technical ceramics from the two sites were fairly refractory with an alumina to silica ratio of close to 1: 3.

When combined with the results from Nyamurondo Homestead, it would seem that smelting in the lowland was more efficient when compared to that in the upland. However, the significance of this interesting hypothesis is diminished by the small sample size from some of the sites and the lack of proper smelting slags from most of the upland sites.

Summary

The sites under investigation have yielded a ubiquitous amount of iron working debris ranging from remains of ore, technical ceramics and slags. The failure to retrieve finished objects and blooms from the studied sites however, has limited the capacity to study the intricacies of forging in the archaeological record. Since the analysed materials form part of a stepped continuum, studying them by archaeometallurgical techniques yields not only information on their physical characteristics but also on the technological process and human activities they are associated with. On the basis of external morphological appearance, microscopic and chemical analyses, the technical operations represented by different suites of materials were delineated and these are iron smelting and primary smithing. For example, remains of partially reduced ore from Baranda and Nyamurondo Homestead can be unequivocally linked with iron smelting just as the associated finds of tap and furnace slags and furnace wall and tuyeres. However, isolated remains of these materials are unlikely to provide useful information for remains such as haematite can be used for other activities not related to iron smelting such as making colourants (Miller and Killick 2004). Smithing slag and crown material represent another stage in the iron production cycle – refining and cleaning the bloom in preparation or in the process of making artefacts. Though representing different stages in the production cycle with smelting slags, smithing slags and crown materials are related chemically reflecting the different inputs in the bloomery process. Although they are morphologically distinct, compositional analyses and ternary plots have established the relationships between the ores, refractory ceramics and the different slags in a stepped up process.

However, within a related process such as smelting, different slags exhibit different characteristics. For example both tap slags and furnace slags can be produced during one smelt but the former have a well-defined flow like structure which can be detected mineralogically and macroscopically. Tap slags also contain less iron oxide when compared to furnace slags because they represent the most fluid part of the slag which contains more silicates and fuel ash oxides. Smithing slags and crown material are usually leucite rich and contains more iron oxide and metallic iron when compared to smelting slags.

Different methods have produced different kinds of data: macroscopic studies enabled the initial classification of the ~~materials into~~ technological groups which were corroborated by microscopic and chemical means. On their part, microscopic analyses revealed important information regarding the microstructures and conditions of operation in the furnaces. ~~Furthermore, they~~ have been crucial in characterising different artefact suites such as tap slags with their typical oxidation skins. Compositional analyses have revealed the major oxides constituting the different archaeometallurgical remains. While ~~they are~~ also important in characterisation studies, it has been shown that they allow the establishment of relationships between the materials related to iron smelting and smithing. Chemical analyses (ternary plots) have also shown the relationship between the different remains with slags falling between the ore and the refractory ceramics. This shows that dedicated archaeometallurgical studies must use more than one method in order to fully understand and reconstruct the technical processes and human activities in the past. More importantly, the different morphologies were confirmed by chemical and microscopic analyses. The other interesting observation, however, was that the undiagnostic slags were more related to the smelting slags and probably reflects the heterogeneity of the process or slags produced using a different recipe.

Having analysed the materials archaeometallurgically, the next stage therefore is to interpret the data from each region in order to get an insight into the major phases in the production cycle and the role of human agency in the smelting operations. This makes it possible to compare the technical parameters of the iron working operations, focusing on the nature of raw materials, the possible addition of fluxing agents, the smelting temperature and the efficiency of the process. However, for the laboratory data to be meaningful, it must be combined with that from other sources such as archaeology in order to have a holistic picture of how iron was worked in the past. The next chapter interprets and discusses the results of metallurgical, archaeological and ethnographic studies so as to obtain a clear understanding of the *chaîne opératoire* of iron working in different periods of the Zimbabwean Iron Age.

Chapter Eight: Discussion and interpretation

Introduction

The object of this chapter is to provide a comprehensive discussion and interpretation of the picture of indigenous iron production presented by the available evidence from the studied sites within an inter-disciplinary framework. We have now collected a range of data (archaeological, ethnographic and archaeometallurgical) from several smelting episodes in northern and eastern Zimbabwe. The interpretation of the metallurgical and archaeological data has identified four types or classes of iron working remains: the ore, smelting slag (flow and furnace slag), smithing slag/crown material and refractory/technical ceramics. These finds correspond with the major stages in iron production namely smelting and primary smithing. On the other hand, the failure to retrieve finished objects has made it impossible to determine the iron fabrication techniques used in the Iron Age of Zimbabwe. A critical analysis of these remains sheds light on human agency in selecting ores and other resources such as clays for constructing furnaces and tuyeres. Furthermore, by interpreting the finds and the contexts of their recovery it is hoped that this study will shed light on the types of ore that were exploited, the technology of smelting used (whether the furnaces were slag tapping or non-slag tapping) and the treatment of the blooms from the furnaces at the selected sites. The occurrence of these categories of iron working remains in the same archaeological contexts indicates that smelting and smithing were probably practised within close proximity. In order to ascertain the relationships between different iron working practices at inter-site and inter-regional levels, there is need for comparison and discussion of the data generated in the previous chapters. By paying particular attention to historically specific cases, it is possible to enumerate different patterns of iron working through time.

Interpretation of the evidence: Swart Village

Although the evidence for iron working is fragmentary, it allows the construction of an outline of the stages in the production cycle revealed by the iron working remains recovered from the site. The archaeological, visual and laboratory study of iron production debris from Swart Village illuminates the existence of a very interesting metallurgical tradition. As shown by the laboratory studies, the smelters exploited a high grade ore rich in manganese. While the ore is low in gangue materials it is notable for containing elevated levels of manganese. In the reduction process, the manganese substitutes for iron oxide in the slag thus enhancing the output of metallic iron from the furnaces (Joosten 2004, Miller and Killick 2004, Morton and Wingrove 1972).

This type of high grade ore, however, can present problems in reduction because it has very low concentrations of gangue materials necessary for slag formation. The abundance of the fluxing elements in the technical ceramics at the site seems to have compensated for the deficiency in the ore. In the reduction process, the silica in the technical ceramics would have reacted with part of the iron oxide in the ore leading to a very efficient slag metal separation. Such a proposition is supported by the observation that most of the tuyeres are corroded further confirming their role in the furnace chemistry to promote the recovery of the metal.

Two samples of natural rocks from the site were analysed chemically together with the ore proper to reveal their elemental compositions. Macroscopically and microscopically, the rocks contained minor quantities of haematite. When compared to the ores, interesting similarities and differences emerged (see Appendix 2). Both the ores and rocks exhibited a very similar geochemical composition with the only difference being in the proportion of compounds such as Fe_2O_3 and SiO_2. For instance, while the real ores had an average FeO content of nearly 80 wt%, the rocks contained less than 15 wt% of the oxide. The most striking similarity, however, is the presence of an elevated amount of manganese of between 8 and 10 wt% in both materials. This suggests that the ore was sourced from an area with a comparable geological composition to that at the site thus pointing to the local source for the ore. It would seem that the ore utilised was likely obtained in the vicinity of the site.

Whilst the finds of tuyeres are abundant, very few fragments of the furnace wall were recovered. While the unvitrified sections of the furnaces are unlikely to survive the passage of time, one would expect the vitrified furnace wall to have a high survival rate just as the tuyeres. Swart Village is in conformity with other reported Early Iron Age sites in the country such as Matanda Farm and Makuru where finds of furnace debris have been very rare prompting questions such as the probable ritual disposal of the furnace superstructure after smelting episodes (Miller and van der Merwe 1994a, b, Phillipson 1985, van der Merwe 1980). Clearly, the failure to recover furnace structures has made it difficult to reconstruct the size and form of the furnaces which were used at Swart Village. Superficially, the large blocks of slag recovered from the site and the large tuyeres show that the furnaces may have been as big as Prendergast (1983) also inferred from the material from Surtic Farm.

Microscopically, the clays used to make the furnace wall had rounded quartz minerals in an ordinary clay matrix showing that there was no deliberately added temper. This contrasted with the tuyere clays in which the quartz grains were angular and looked like they were deliberately crushed and added as tempering material. Though the sample size for the furnace wall is very small, this point to the possible differential treatment of clays used to make tuyeres and the furnace wall at the site, a practice recorded in the Great Lakes region of east Africa (Childs 1989, Humphris 2004). Despite the fact that this differential treatment is not reflected chemically, it seems that human choice was primarily responsible for these variations in the use of clay resources at the site.

The high amount of silica (average 60 wt%) in the technical ceramics played an important role in the furnace reactions by combining with some iron oxide to form fluid slag (Schmidt 1997). The limited amount of siliceous materials in the ore (c. 2 wt%), the eroded ends of the tuyeres and the enriched amounts of silica in the slag (see below) point to the technical ceramics as the main contributors of the fluxing material unless the smelters made innovations and technological choices such as deliberately adding sand in the furnaces, a practice that has been noted in the Phalaborwa region of South Africa (Miller *et al.* 2001, Miller and Killick 2004) where extremely rich iron ores were smelted.

To understand whether there was a conscious use of different clays for specific purposes at the site, samples of domestic pottery and architecture (pole impressed daub or *dhaka*) were prepared for optical microscopy and for chemical analyses. Mineralogically, the clays from the two categories of material culture exhibited interesting differences. The pole impressed daub contained the ordinary clay matrix without any additives meant to alter its properties while that for domestic pottery had added magnetite sand. This microscopic observation was corroborated by the high amount of iron oxide (c. 14 wt%) shown by the chemical analyses of several fragments of domestic pottery. The tempering of tuyere clay with magnetite would have had negative effects suggesting a conscious and deliberate treatment of clays for specialised tasks at the site. Besides the tempering materials, the compositional pattern of all the clays is analogous suggesting that they were sourced from geologically related places.

The slag from Swart Village is diagnostic of two metallurgical processes: smelting and primary smithing. Most of the slag from the site is dense with clear evidence of flows and attached sand grains at the bottom; the proven attributes of tap slags (Bachmann 1982, Miller and Killick 2004). While exhibiting evidence of different runs, the slag has grooved deformations some of which have impressions of bark. What is particularly striking is that the impressions are imparted on the flow structure tentatively suggesting that they were a post reduction phenomenon. Probably, tree branches were placed on slag upon its removal from the furnace. Whether this was a method of removing slag from the furnaces or not is not clear. In the absence of in situ furnace remains, it becomes difficult to understand either how the furnaces were constructed or their method of operation.

Microstructurally, the bulk of the flow slag analysed show evidence of tap lines or magnetite skins that separate individual slag flows. The fayalite in a significant number of samples has formed perpendicular to the slag flows, a structure earlier on referred to as spinifex. Informed metallurgical opinion contends that such a microstructure is consistent with slags which would have cooled rapidly, outside the furnace (Joosten 2004, Killick 2004c, Miller and Killick 2004). Attached sand grains which appear shattered due to exposure to the residual heat from the flow slag further indicate the existence of slag tapping at Swart Village. Again, this interpretation remains tentative as it is not backed by the recovery of actual furnaces which could have shed light on the methods of slag removal from the furnaces for example whether tapping holes existed or not. What is clear is that the slag has got several flow structures which have been detected visually and microscopically. Also, there is a high proportion of tap slag (44 % of the remains) at the site when compared to the furnace slag (25%). While some furnace slags can develop some flow structures, they normally contain charcoal and clay encrustations at the base rather than sand grains (Pleiner 2000, Prendergast 1983, Schmidt 1997). On the basis of the existence of run out slag with rippled surfaces and sand grains attached to the base of slag, Prendergast (1983) has defined slag tapping at Surtic Farm, an EIA site found in northern Zimbabwe. Furthermore, he predicted that future research had the potential to reveal more sites that were contemporary with Surtic Farm containing clear evidence of slag tapping.

Clearly, there are some slags which solidified in the furnaces. This does not rule out the possibility of slag tapping at Swart Village for slag tapping furnaces are known to produce furnace slag as well. The furnace slag is replete with impressions of charcoal and or thin sticks emanating from the contact between the slag and the charcoal bed or logs at the base of the furnace. Though the furnace slag exhibited similar phases to those of tap slag, it was devoid of tap lines and spinifex structures. In addition, while the fayalite laths were skeletal in the tap slag, they were blocky in the furnace slag showing that the two types of slag had cooled at different rates. The relative proportions of phases and elements in the smelting slags from Swart Village indicate that the reduction at the site was fairly efficient and typical bloomery products as between 60 and 70 wt% iron oxide was retained in the smelting slags.

The other metallurgical finds of interest from Swart Village are two diorite hammerstones, possible anvils, crown material and smithing slag. The hammerstones were flaked at the bottom end that was used for striking objects (**see Chapter 5**) while the anvils were very smooth. This alludes to the existence of primary smithing at the site in similar contexts with iron smelting. On the other hand, there is a possibility that the hammerstones could have been used in ore preparation although the evidence for this is rather circumstantial. For example, Swan (pers comm.) has found hammerstones and anvils in association with a sizeable amount of magnetite nodules of different sizes at Mangula in southeastern Zimbabwe. Due to the lack of associated ore finds, the anvils from Swart Village are more consistent with smithing activities at the site. Also, this interpretation (of ore preparation) is rejected by the fact that the anvils and hammerstones were recovered in association with slag only. In addition, ore preparation would typically have left small holes on the anvils (Swan 2002). Some finds of possible hammerscale were recovered when a magnet was run through the soil excavated from the trenches. The flakes were highly magnetic and larger than the magnetite which naturally occurs in soil further strengthening the case for the co-existence of smithing and smelting at the site.

Macroscopically, the material identified as smithing slag was very rusty and heavy demonstrating that they had a sizeable amount of metallic iron. Microstructurally, the smithing slag/crown material was dominated by metallic iron with other phases such as wuestite and fayalite coming in different proportions. As Greenfield and Miller

(2004) have posited the occurrence of such material at Ndondondwane, an EIA site in South Africa, points to the practice of iron smithing at the site. Equally, Crew (1991, 1998) has argued that the existence of crown material is an indicator of primary smithing as fragments which are knocked off the bloom. Chemically, the crown material/smithing slag posses a very high amount of FeO (average c. 75 wt%) which in most cases is more than the amount that is found in smelting slags *i.e.* tap and furnace slags. Overall, the morphological classes of slag are reflected in a slight but systematic variation in composition, consistent with the different fluidity of the various slag types.

A careful analysis of the excavated iron working remains from Swart Village shows that most of the evidence from all the trenches was dominated by iron smelting slags even though some smithing slags were produced. In the absence of detailed studies on the settlement lay out at Swart Village and a really well-defined stratigraphy, it is difficult to state that smelting was taking place in the same place and exactly at the same time as communities living there. However, the co-occurrence of smelting, smithing and habitation material at the site is suggestive that all these practices were taking place at the same time.

Interpretation of the evidence: Baranda

The metallurgical finds recovered during the excavations conducted on Baranda Farm give a glimpse into the technology of iron working in the 16th and 17th centuries. Finds of ore were recovered together with broken tuyeres and tuyere plugs in Trench 3. The ore exhibited a purplish colour which is consistent with partially reduced ores, finds which are commonly found upon the termination of individual smelting episodes (Chirikure and Paynter 2002, Greenfield and Miller 2004, Joosten 2004).

Chemically, the ore was manganiferous with an average quantity of c. 8 wt% manganese. This concentration and that of most other compounds is very similar to that of the possible ore from Swart Village. This is not to suggest that the ores exploited at the two sites were necessarily mined from the same locality but that they were recovered from geochemically related ore bodies. In discussing human choice in ore selection at Baranda, one is limited by the absence of enough comparative material. However, the banded iron stone from northern Zimbabwe is known to contain different levels of manganese (Prendergast 1974).

Finds of broken tuyeres and furnace wall were also retrieved from Baranda. Mineralogically, the clays for tuyeres and furnace walls exhibited different characteristics with that for tuyeres possessing a smooth texture while that for furnace walls was coarse grained. Both types of clays were not tempered.

Chemically, the clay had enriched levels of alumina averaging (c. 22 wt%), as compared to an average of only c.18 wt% in the furnace wall material enabling it to withstand the high temperatures involved in smelting without crumbling. Given the higher levels of alumina in the technical ceramics, the slagged nature of their ends suggests that fairly high temperatures (around 1200° Celsius) were achieved in the furnaces (this was also shown by ternary plots). Also, the tuyere clay has more phosphorous and calcium when compared to the furnace clay. This is suggesting a different clay source for the materials an observation supported by the discrepancies in the texture of furnace clay (coarse grained) and tuyere clay (smooth).

As with Swart Village, finds of domestic pottery and house floors were analysed in the laboratory. Mineralogically and macroscopically, the clays had some insightful differences with the technical ceramics. The clay from house floors was rather loose with a coarse texture shown by the presence of large quartz grains (35 %) in the clay matrix. Clearly, the clay was not tempered. The clay of the domestic pottery was fine textured with about 15% quartz grains. In terms of major oxide composition, the house floor clay and that from pottery exhibit a similar composition suggesting a related geological origin.

From a combined visual examination and laboratory investigation, the smelting slag from Baranda falls within the typical range of bloomery slags. Morphologically, the pieces of slag are very small with some being dense and having a clearly defined flow structure. The majority of the slag is consistent with furnace slag. Under the microscope, the major phases represented were primary dendrites of wuestite, silicates, porosity and minute quantities of hercynite. The slags have got elevated amounts of alumina, potassium and calcium. However, the possible ore from the site is deficient in these elements which are found in the technical ceramics. This raises questions about the possible role of technical ceramics in the slagging process.

When compared to Swart Village where most of the slag was consistent with flow slag, very few pieces of slag at Baranda exhibited features of tapped slag. Such samples had well developed magnetite skins that separate individual slag flows. The bulk of the slag however was the typical furnace slag dominated by wuestite and fayalite in a glassy matrix and lacked the characteristics of tapped slag. This raised questions about the methods of slag removal at the site. The small low shaft furnaces likely to have been used at Baranda are believed to have been non-slag tapping. However, they possess a frontal opening known as a rake hole where slag was scraped out of the furnace upon termination of the smelt. Some of the liquid slag possibly trickled out of the furnace assuming the shape of tapped slag while the majority was removed as a block with the characteristics of furnace slag. Such furnaces are common in the Late Iron Age of Zimbabwe, particularly after the 15th century. Examples of such bellows driven furnaces have been recovered by Prendergast (1979b) in the Masembura communal lands (dating to the 16th century) and by Bernhard (1962) in Nyanga dating to the 17th century.

One of the stages represented by the metallurgical finds from Baranda is primary smithing, revealed by the recovery of smithing slag and crown material. Morphologically, the possible smithing slags and crown material were coated with corrosion while some of the material had charcoal inclusions. As indicated by being magnetic, the crown material contained large amounts of metallic iron. Mineralogically, the smithing slag and crown materials were dominated by wuestite, fayalite and metallic iron. As shown before, the microstructures of smithing and smelting slags grade into each other, forming a continuum. This makes it difficult to distinguish the two groups of slag. Noteworthy is the fact that the samples macroscopically identified as smithing slag and crown material have got an elevated amount of FeO when compared to smelting slags.

After identifying smelting and smithing at Baranda, the next issue to consider is whether there was any temporal or spatial relationship between smelting and smithing at Baranda. Although stratigraphic separation at the site was not good, the distribution of activities at the site sheds light on the spatial organisation of different activities. Pikirayi's (1993) in depth study of the distribution of artefacts at Baranda has shown that there seem to be some areas associated with exotic goods only while others are associated with local material culture. Iron smelting and smithing appears confined to the western region together with house remains and local pottery. The dominance of iron working in this area is demonstrated by the existence of remains of partially reduced ore, tuyere plugs, and tuyeres with reduced ends. It is also clear that there is no occupation layer that was dominated by smithing alone to suggest that smelting would have been done elsewhere. Finds of broken tuyeres, tuyere plugs and slag were also found at the surface as well as from almost every layer of Trench 3 showing that iron was probably smelted during the entire occupation at the site.

Interpretation of the evidence: Wedza

The metallurgical finds comprised of possible ore, broken tuyeres, collapsed furnace walls and slag. Microscopically, the ore associated with the slag was dominated by iron oxide with little inclusions such as silicates. Chemically, the ore had an average FeO content of c. 85 wt% with minor quantities of silica and alumina. Two samples of haematite were also collected from the historical mines nearby (see Chapter Six) and analysed to determine if the ore could have been used to produce the slag at the smelting site. The samples from the mines were clearly low grade ore containing on the average c. 27 wt% iron oxide. The ore is "clean" suggesting that the slags may have been produced from a similar ore albeit with a higher iron oxide content.

Macroscopically, the probable furnace wall was vitrified in the inside and had slag encrustations whilst the tuyeres were reduced at the ends. Microscopically, there was a difference in the texture of clays used to make the furnace wall and the tuyeres. Furnace clay was very coarse (rough and unrefined) while tuyere clay was smooth (fine grained). Chemically, the clays have an identical ratio of silica to alumina which is on the average 3:1.

What is striking is the high ratio of 6 (silica): 1 (alumina) reflected in the slags compared to the 3:1 in the clays. There are two possible reasons for this discrepancy. Firstly, the Njanja smelters may have blended the high grade with the low grade ores rich in siliceous impurities. Alternatively, Njanja smelters may have exclusively smelted a high grade ore and added sand to help the furnace reactions as in the case of Phalaborwa, northern South Africa (Miller and Killick 2004) (see Chapter Two). In the absence of evidence for deliberate fluxing in the historical documents and the difficulty of detecting it metallurgically, such an interpretation will only remain a possibility.

The ratio in quantity of flow slag to furnace slag at the site is 2:1. The samples classified as flow slag had very little wuestite, the rest being fayalite which was intergrown with interstitial glass. Some samples also contained minute grains of metallic iron. Furthermore, the flow slag had well developed oxidation layers (magnetite skins) that separated the individual slag flows. This observation was matched by the very low amount of FeO content on the average 58 wt%. While exhibiting the same microstructures, the furnace slag from the site had a slightly high average FeO content of c. 66 wt%. Both types of slag had very low amounts of leucitic inclusions. The enriched levels of calcium (c. 3 wt%) in the slags were probably inherited from the fuel ash because the ore has none and the technical ceramics have only 2 wt% CaO. Clearly, the iron reduction at the site was very efficient because very little residual iron oxide was left in the slag.

Does the efficiency of Njanja iron smelting imply that there was slag tapping as suggested by Morton and Wingrove (1972)? Far from it, even though no intact finds of furnaces were made, the bases of furnaces observed at the site neither possessed slag pits nor tapping holes. In addition, macroscopical analyses of the flow slag recovered at the site did not reveal the existence of slag runners associated with tapped slag. Also, historical documents have shown that the Njanja furnaces were non-slag tapping. Typical Njanja furnaces were similar to those used in the Late Iron Age which consisted of a large frontal rake hole and a low shaft standing above the ground. The major difference was that Njanja furnaces were modified; possessing four to six tuyeres which used two to three pairs of bellows (see Chapter 4). With an increased air provision implied by the use of many air inlets and bellows, most of the slag became molten and free-flowing to the extent that when the rake hole was opened; much of the slag assumed the features of tapped slags. Some of Mackenzie's informants recounted that red hot slag (which they confused with metal) dripped out of the furnace in a molten state (Mackenzie 1975).

Smithing hearth bottoms from Wedza consist of layers of deposits that included charcoal mixed with ash and slag. Microscopically, the smithing slag was similar to furnace slag, containing the same phases although in different proportions. The smithing slag contained higher levels of wuestite and leucitic inclusions than the furnace slags. Sample W-sm3 contained about 5% metallic iron with some wuestite transforming into metal. This material was probably crown material as it exhibited features which are identical to those diagnosed for the material at other sites. The recovery of a smithing hearth adjacent to a large and smoothed rock (see Chapter Six) which arguably performed the role of an anvil further shows that smithing was practised in proximity to smelting areas.

Because the Njanja iron production was market oriented (and responded to a high demand for iron covering a wide area), it was organised differently from that of its contemporaries. During the late 19th and early 20th centuries, Njanja iron working was organised along industrial lines in the vicinity of habitation areas thus giving it easy access to labour. While some Njanja people were mining the ore, some were busy smelting in the vicinity of the mines selling their products on the way home. That the Njanja had itinerant smiths who travelled to distant places smelting iron shows that their knowledge of iron working was not a closely guarded secret. This shows that the spatial configuration of their industry was determined more by factors such as access to resources and the dictates of the market.

Interpretation of the evidence: Nyanga

The metallurgical finds recovered from both Upland and Lowland Nyanga are diagnostic of three processes namely ore preparation, smelting, and primary smithing. Finds of ore have only been recovered at Upper Pungwe on a rock surface that was most likely used for ore preparation. The ore was hydrated iron ore (limonite) with a yellowish colour. The ore was high grade with minor quantities of alumina (c. 4 wt%) and silica (c. 4-7 wt%).

The recovery of a slag block which contained unreacted haematite in the slag matrix offered an insight into the likely ore exploited at Nyamurondo Homestead in lowland Nyanga.

Both microstructurally and morphologically, the smelting slags from eastern Zimbabwe exhibited uniform characteristics. Most of the smelting slag was recovered from the lowland sites with few samples from Nyamuzihwa Falls and Demera in the upland. Samples of flow slag from Nyamurondo Homestead and Nyamuzihwa Falls varied considerably. While that from Nyamurondo Homestead had rippled surfaces similar material from Nyamuzihwa Falls was only partially fluid. This was revealed metallographically because tap slags from Nyamurondo had fully developed tap lines and spinifex structures while such features were not well developed in the Nyamuzihwa Falls material. This also shows that the Nyamurondo Homestead material was more fluid when compared to that from Nyamuzihwa Falls. Tap slags from the two sites had different levels of FeO. While the flow slags from Nyamuzihwa Falls had between an average FeO content of c. 75 wt% that from Nyamurondo Homestead was much lower with an average of c. 65 wt% FeO. Also, there are notable differences in oxides such as calcium, potassium and phosphorous which are much higher in the Nyamurondo slags than those from Nyamuzihwa Falls. The elevated amount of typical fuel ash oxides (calcium and potassium) in the Nyamurondo material suggests that a higher fuel to ore ratio was likely used at the site when compared to Nyamuzihwa Falls. Overall, iron smelting at Nyamurondo was more efficient than that at Nyamuzihwa.

The phase identification using reflected light microscopy has demonstrated that the furnace slag samples from eastern Zimbabwe had primary dendrites of wuestite in the range of between 50 to 65%. The fayalite was blocky indicating that the slag had cooled slowly in the cooling furnace. Noteworthy is the fact that these slags from all the sites analysed here are very rich in hercynite which when viewed under the microscope ranges between 10 and 15 % on the average. The material from Demera was more hercynitic. The furnace slags from Nyamurondo and Nyamuzihwa Falls have got a variable chemical composition reflected in the flow slag. Again, furnace slag from Nyamurondo stand out as being lean in FeO and rich in typical fuel ash elements (CaO, MgO, K_2O, P_2O_5) further confirming that smelting at the site was largely efficient and that a high fuel to ore ratio may have been used at the site.

Judging from the elemental and chemical composition of the smelting slags, it can be asserted that smelters in the Nyanga Complex used different furnace types with different levels of skill and efficiency. Also, the fact that most of these slags are wuestite dominated suggests that the product from these furnaces was likely to be soft iron though at times variable low carbon steels were also produced (Killick 1990). Due to the dearth of finished objects from the area, such statements are only indicative but remain largely uncorroborated by the evidence.

The smithing slags and crown material from Nyanga were diagnostic of primary smithing. Samples of crown material from Upper Pungwe and Demera had a related mineralogical composition. While some samples were rich in metallic iron (approximately 30%) others were more wuestite dominated and only contained metallic iron of close to 5%. Obviously, the later samples are transitional between the furnace slag and crown material, an observation supported by the fact that some of the wuestite is visibly transforming into metal. Their interpretation as smithing slag is supported by the fact that the material from Demera was recovered adjacent to a very low structure interpreted as a smithing hearth. While deficient in metallic iron, the smithing slag from Nyamuzihwa Falls was dominated by leucitic inclusions when compared to the smelting slag from the same site. Like the smelting slags from eastern Zimbabwe, the smithing slag is hercynite rich.

A closer look at the texture of furnace clay and tuyere clay reveal differences in the choices of clay. For example, tuyere clay is very fine textured while furnace clay is rough. There is no evidence for direct tempering of tuyeres recovered from sites such as Nyamurondo Homestead. However, the furnace wall from Upper Pungwe contained small lumps of rocks which may have been deliberately added to strengthen it. Chemically, the clays used to make tuyeres and furnaces are rich in alumina. Some of the furnace walls were slagged and bloated. Microstructural analysis of such sections revealed dendrites of wuestite intergrown with fayalite and interstitial glass indicating that some absorption of ceramic material into the slag did occur. These samples were taken off intact furnaces on the edges of Ziwa Mountain (Ziwa 1, **see Fig 33g**) and Sangura Hill. In the vitrified sections with no slag, minute quantities of iron oxide in the clay had been reduced to metallic iron showing that highly reducing conditions had been achieved. Temperature gradients in the ceramics could be seen from the outside where the original structure of clay was apparent to the vitrified inside where chemical reactions in the furnace were taking place. It appeared as if the Ziwa 1 furnace was deliberately cleaned after use as no slag pieces were viewed in the vicinity despite the existence of anvils and broken hammerstones near the furnace.

Most of the eastern Zimbabwe furnaces are located in low walled stone enclosures with an average diameter of 3.5 metres (see Fig Chapter Six). Such enclosures have not yet been documented elsewhere in Zimbabwe evoking questions regarding their possible function. From a functional point of view, the walls are too low to conceal the activities taking place inside. Soper (2002) has suggested that the walls represent some form of symbolic isolation. However, it is also possible that the enclosures were built to define the space in which smelters worked and thus may not have had any symbolic connotations. Also, these stone walled enclosures are located in proximity to settlement areas such as pit structures, enclosures and agricultural terraces while others are located in isolation showing variation in the spatiality of iron working within the Nyanga Complex. What is even more intriguing is the fact that in addition to being close to habitation areas, some of these furnaces are gendered as they contain moulded features of breasts, navels, female genitalia and waist belts (see Chapter 6) while others were designed to look like women giving birth (see Bernhard 1962, Soper 2002). These anthropomorphic features reveal beyond any reasonable doubt that fertility symbolism pervaded Nyanga iron smelting even though smelting was mostly practised near settlement areas.

A comparative perspective on iron working in the Iron Age

This section seeks to compare iron working from the different records with a view to establish continuities and changes in the production of iron over time. The comparison was based on technological attributes and socio-cultural factors such as furnace types, slag chemistry, tuyere sizes, methods of blowing and whether the furnaces were slag tapping or non-slag tapping and the presence or absence of cultural representations. To facilitate the comparisons, a table was designed to capture the most salient features of the major stages in the production cycle exhibited by the studied materials from the case studies. The whole comparative procedure was aimed at understanding variation on two levels: natural constraints and human agency. Natural constraints such as local geology and the nature of the ore often cause variation and stimulate innovation in iron smelting practices over time.

Table 17 Key characteristics of iron working at Swart Village, Baranda, Nyanga, Njanja, Kalanga and Karanga

Variable	Swart Village (EIA)	Baranda (LIA)	Nyanga (18th/19th century	Njanja (19th/20th century)	Karanga (19th century)	Kalanga (19th century)
Ore	Manganese rich (haematite)	Manganese rich (haematite)	(Alumina rich laterite? and limonite)	Haematite (clean)	Haematite (clean)	Laterite (Alumina rich?)
Furnace size	Large (over 1m at base?)	Small (0. 7m at base?)	Small/medium (0. 7 to 0. 9 m at base)	Medium (0. 9 to 1m at base)	Small (0. 7m at base)	Small (0. 5m at base)
Furnace clay	Coarse grained	Coarse grained	Coarse grained, tempered with rock inclusions (Upper Pungwe)	Coarse grained From swamp areas	Fine grained from anthills	Coarse grained
Internal Diameter of tuyeres	50-60 mm	25-30 mm	35-40 mm	35 - 40 mm		
External diameter of tuyeres	70 – 80 mm	35 – 40 mm	45 – 50 mm	45 – 50 mm		
Tuyere clay	Fine grained (tempered with quartz)	Fine grained (no temper)	Fine grained (no temper)	(fine grained no temper)	(Fine grained, no temper)	(Fine grained no temper)
Method of Air supply	Natural draught?	Bellows	Bellows	Bellows	Bellows	Bellows
No. of tuyeres	Multiple?	Two?	Two/three	Four/six (fused in pairs)	One	Two
Slag removal method	Tapping?	Raking?	Raking	Raking	Raking	?
Decoration	?	?	Yes	Yes	None	Yes
Rituals and taboos			Present	Present	Present	Absent
Location of smelting	Within villages	Within villages	Within/outside villages	Within/outside villages	Outside Villages	Within villages

As shown in the table, the process of iron production in Iron Age Zimbabwe as elsewhere in southern Africa thrived on the same fundamental bloomery process. The first step in the comparative procedure was to compare the practice of iron working at

Swart Village and Baranda (EIA and LIA) in northern Zimbabwe on the one hand and between northern and eastern Zimbabwe on the other. Despite exploiting a more or less related ore which was rich in iron and manganese, smelting at Swart Village and Baranda had different outward features showing the existence of distinct iron extraction traditions at the sites. A visual analysis of the technical ceramics and slag from Swart Village revealed important differences with similar material from Baranda. As shown by the table, smelters at Swart Village used thick walled (10 mm) and large tuyeres approximating 60 mm internal diameter while those at Baranda used very thin walled ones (5 mm) with an internal diameter of 25 mm. Laboratory analyses have shown that while the tuyeres and furnace wall from Swart Village were made of identical clays, those from Baranda were made using clays with different refractory qualities. Chemical analyses have revealed that the tuyeres from Baranda were rich in phosphorous oxides and alumina and a matching lower silica content. This may indicate a conscious selection of more refractory clays at Baranda, and is further reflected in the much thinner walls of the tuyeres when compared to those from Swart Village. If one considers the fact that the tuyeres from Swart Village were tempered with crashed quartz, which is not particularly refractory it becomes clear that the smelting traditions at the sites were designed differently as the Swart Village tuyeres would contribute more to the furnace chemistry than those from Baranda. The thinness of the tuyere walls from Baranda indicates a high level of skill in their use because they lasted the duration of the smelt without blocking. It is tempting to speculate that tuyere clay was probably a response to limited availability of this clay and a selection of it for more demanding parts of the furnace design. However, more fieldwork targeted at provenancing the different clays would provide more useful information than is currently available. If the assumption is right that the earlier furnaces were natural draught and relatively big, probably with many tuyeres, and the later furnaces small with just a few tuyeres, then there would be considerable pressure on the performance characteristics of the later tuyeres; failure of just one out of one or two tuyeres would have had a much more severe effect on the smelt than in the typical multi-tuyere natural draught furnaces.

Does this variation in tuyere sizes (**see Fig 64**) imply different methods of blowing the furnaces at the sites? Mackenzie (1974b) has suggested that drum bellows could have been used with the large tuyeres from the EIA while bag bellows were used with the smaller LIA tuyeres. In this case the change from the drum bellows to bag bellows may have been necessitated by the need for more efficiency. This supposition however, is speculative as it is not supported by any tangible evidence. Implicitly, it has been claimed that the large diameter (both external and internal) tuyeres such as those from Swart Village suggests that the furnaces used at the site were large and powered by natural draught. From a functional point of view, it is difficult to connect bellows to such tuyeres (Pleiner 2000, Rostoker and Bronson 1991). Even anecdotal evidence has shown that most natural draught furnaces have large tuyeres exceeding 50 mm internal diameter (Mapunda 2003). On the basis of large diameter tuyeres, Prendergast (1983) has proposed the existence of natural draught furnaces at the EIA site of Surtic Farm in northern Zimbabwe. Again it is tempting to conclude that most of the EIA furnaces at sites such as Tafuna Hill (Garlake 1971a and Chapter 3) were also natural draught driven. Zimbabwe is the southern limit of natural draught furnaces (Killick 1991b, Gordon and Killick 1993) and more research will add light on this interesting technology which is well documented north of the Zambezi River. Of course, one has to be aware that there is no simple one to one relationship between tuyere size and method of blowing the air into the furnaces. Thus, future research should be targeted at recovering furnace superstructures which may help to bring more light on this issue of natural draught furnaces.

These large furnaces most likely to have been used in the EIA significantly contrast with the small bellows driven furnaces which were utilised at Baranda and other sites in LIA northern Zimbabwe. In this case the change from the large natural draught furnaces to the small bellows driven furnaces may have been prompted by the need for greater efficiency. The major disadvantage of natural draught furnaces is that they consume large quantities of charcoal with devastating consequences to the environment (Haaland 1985, Gordon and Killick 1993, Mapunda 2003, Rehder 2000). In addition, it takes several days to produce in them. Bellows driven furnaces are also limited in that they require a lot of labour in pumping the bellows. However, their major advantage is that one can produce iron in a short space of time by using less charcoal. Probably, the fact that bellows driven furnaces were used with great success in most of the later smelting traditions such as the Njanja with great success shows that their users may have realised that they were more efficient in time when compared to the natural draught ones.

Figure 64 photograph showing differences between tuyeres from Swart Village and Baranda

Figure 65 tuyeres fused in pairs, Wedza surface collections

The morphologies of the slag from Swart Village and Baranda further show the variation in iron working practices at the two sites. While most of the slag from Swart Village comprise of fluid but large blocks with semi-circular depressions, most of the slag pieces from Baranda were comparatively smaller and less fluid. This macroscopic observation provides further support to the supposition that earlier furnaces were of a different design and larger than the later ones. Mineralogical analyses have revealed that most of the slags from Swart Village appear to have been tapped an observation supported by morphological studies. This tapped slag from Swart Village is replete with magnetite skins and low wuestite frequently associated with tapped slag (Morton and Wingrove 1972, Okafor 1993). There are other EIA sites in northern Zimbabwe which have produced possible evidence of slag tapping. The site of Surtic Farm has also yielded a lot of tap slag prompting Prendergast (1983) to conclude that the furnaces used at the site may have been both slag tapping and natural draught driven. While, some of the slag from Baranda exhibits well defined flow structures and oxidation layers that separate flows were visible microscopically, the bulk of the slag was typical furnace slag which solidified in the furnace. This variation in the by-products shows the existence of different iron smelting recipes at the two sites with the earlier one producing more fluid slag than the later one. Overall, this possibility of tapping in the EIA contrasts with the later furnaces which were non-slag tapping indicating not only variation in furnace design, but also differences in methods of furnace operation and slag removal in the two periods.

Outwardly, there are major differences between iron working at Swart Village and that from Nyanga and Wedza in eastern Zimbabwe. Again, the tuyeres used at Swart Village stand out as for being very large when compared to those from Nyamurondo Homestead and those from Wedza which were fused in pairs. Also, large blocks of slag which had a clearly defined flow structure and grooved deformations have not been detected at these later sites. While the furnaces at Swart Village may have been powered by natural draught those in use from the 17th century in eastern Zimbabwe were bellows driven. While Swart Village, Wedza, and Nyamurondo Homestead have all produced flow slag, only Swart Village has some slag runners while the sites from eastern Zimbabwe do not have them. Mineralogically, the magnetite layers that separate individual slag flows are more pronounced at Swart Village than at the other sites.

Macroscopically, it is also possible to separate iron smelting at Baranda from that practised at Wedza and Nyanga on the basis of differences in tuyere sizes and slag morphology. The tuyeres used at Baranda stand out as very thin with a small average internal diameter as compared to the tuyeres from Wedza and Nyanga which have got almost identical diameters (see table above). Still on macroscopic differences, the Wedza tuyeres which are fused in pairs have no counterparts in Nyanga. This further shows the existence of separate smelting practices even within the historical period.

Chemically and mineralogically, there is variability in the slag composition between the individual sites on two levels: natural constraints and human agency. For natural constraints, three local geologies have played a huge role in the variability exhibited in the slag chemistry and possibly morphology. The first group consists of the manganese rich slags (average c. 9 wt%) from Swart Village and Baranda. Clearly, this shows the influence of the manganese rich ore which was exploited at the sites. The Precambrian schists which host most iron ores in northern Zimbabwe are known to be manganiferous (Prendergast 1974). Other slags analysed from archaeological sites such as Gwebi Junction by Prendergast (1975) had a high manganese level further showing the manganiferous nature of the geology of the region. The outward differences between iron smelting at Swart Village and Baranda shows that the smelters at the sites responded differently to the local geology. This shows variation in technological choices adopted by iron workers at the two sites. The second group basically consists of the alumina rich slags from the smelting of lateritic ores in

Nyanga. The slags were hercynite and alumina rich when compared to those from Wedza and northern Zimbabwe. The third group is associated with the use of the "clean" haematite from Wedza. This group is characterised by very low levels of oxides such as manganese and alumina. Generally, different technologies were designed to exploit the available ores/geology and in the process stimulating innovation and change over time. Prendergast (1975) has argued that the natural draught furnaces used in the Darwendale area (Chapter 3) were probably designed to smelt a manganese rich magnetite that was found at several smelting sites in the region. The Njanja technology was likely designed to reduce the Wedza ore with a great level of efficiency.

Whilst geology has largely determined the variability in the chemistry and mineralogy of the slags from eastern and northern Zimbabwe, human agency also played a major part. This is amply supported by the differences in the levels of major and minor oxides such as FeO, CaO, K_2O, MgO and P_2O_5 in the smelting slags from the individual sites. The relative quantities of these oxides in the slags is largely determined by human skill in areas such as furnace air provision and the ratio of fuel to ore which can improve the yield of metallic iron from the furnaces. In the three groups discussed above, slags which are lean in FeO inversely contain elevated amounts of typical fuel ash oxides, CaO, K_2O and P_2O_5. This inverse relationship of FeO and these minor oxides is reflected in tap and furnace slags from all the sites. However, when the individual sites are compared, interesting differences emerge. Smelting slags from Wedza and Nyamurondo Homestead have a high amount of CaO which corresponds to the lower FeO level. It seems that the smelters at the sites mostly used a high fuel to ore ratio which leads to the differences in the levels of CaO for instance. In addition, an increase in the blowing rate can lead to an increase in the slag metal separation. In this case, with four to six tuyeres which were connected to two/three pairs of bellows, the Njanja process led to an efficient reduction process which led to the production of very lean slag. Also, Nyamurondo Homestead seems more efficient when compared to sites in the same region such as Nyamuzihwa Falls operating with more or less the same ore. It appears that later smelting traditions at Wedza were more efficient and advanced than those employed at Swart Village and Baranda for instance. This also indicates the different levels of skill in operating furnaces between these sites and regions.

What do these differences in efficiency in the reduction process at the individual sites tell us about human agency? For the Njanja, their efficiency is well linked to their skill, advanced method of smelting and the large scale and market oriented nature of their production. The Njanja technology was well-developed utilising more tuyeres and bellows than any smelting tradition documented in Zimbabwe so far. Studies into the emergence of social inequalities and the organisation of production have demonstrated that producers improve their methods of production and skill in order to meet the demands of the market as well as to increase their own wealth which can be used in expressing greater social differentiation (Costin 2001, Costin and Hagstrum 1995, Hayden 1995, 2001). These technological improvements enabled the Njanja smelters to meet the ever increasing demand for their iron. Also, the Njanja matched these technical modifications with a professionally organised semi-industrial production based on a well-defined division of labour (see Chapter 4). For example, in times of high demand the Njanja operated up to twenty furnaces at a time using a shift system of labour. Also, while some were smelting others were selling the finished product. In this way they were able to meet the demands of a very large market, an achievement which drew admiration from Europeans and locals alike as we have seen in Chapter Four. In the Njanja case, this specialisation may have stimulated technological innovations which in turn increased production. It can therefore be argued that through innovation, the Njanja developed a market orientated iron based economy. In Nyanga, production at Nyamurondo Homestead has yielded the largest amount of iron working remains of all the studied sites in the region. It would seem that the smelting at the site was beyond the immediate needs of the producers at the site. Also, this suggests the existence of specialist iron workers who may have traded their iron in the Nyanga Complex. The Njanja and Nyamurondo cases clearly shows that later smelting practices were more advanced in areas such as metal recovery when compared to Swart Village and Baranda which are earlier.

With this apparent difference between early and later smelting practices documented so far, it is important to consider the role of taboos and rituals over time. For the earlier period however, no evidence has been recovered to give an insight into the nature of taboos. At least it is known that by the 14th century, smelters in Zimbabwe used medicines which were located in a hole at the bottom of the furnace as shown by the discovery of typical medicine holes at the base of a furnace excavated by Prendergast (1975). However, it is not known whether such a practice was also practised in the EIA demonstrating the importance of recovering furnaces dating to the period. What is clear is that most 19th century smelters including the Njanja used medicines of some sort to neutralise the power of witches. This fear of witchcraft probably reflects the general fear that was characteristic of society as a whole and thus was not necessarily limited to smelters alone (Bourdillon 1976).

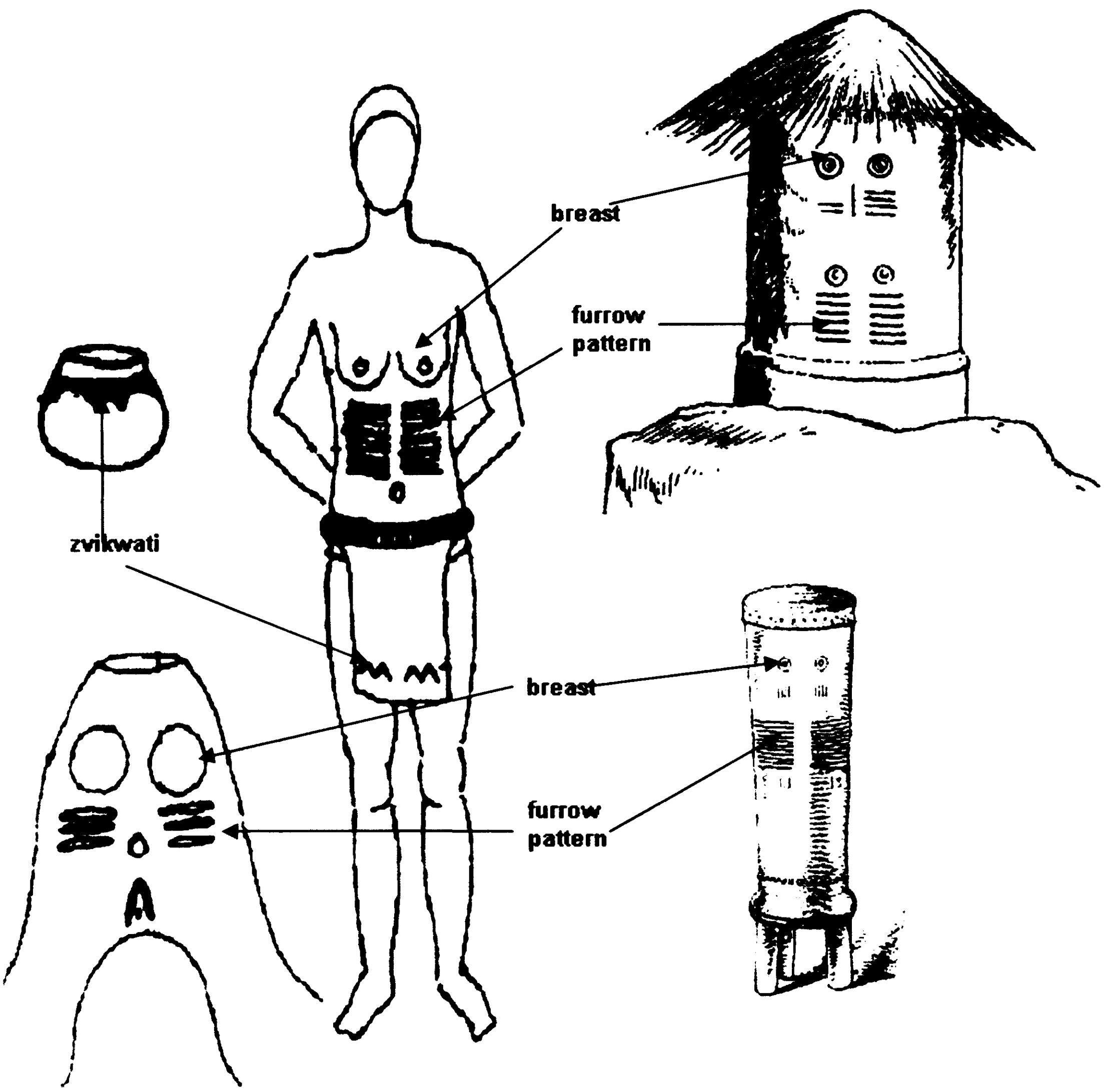
The next issue to consider is the role of reproductive symbolism in iron smelting in Zimbabwe. Some of the furnaces studied in this work were clearly gendered as they contain human features such as breasts and items worn to enhance fertility of women such as waist belts. The furnaces from Upper Pungwe and Ziwa 1 are typical examples. It is known that the Njanja furnaces were also decorated with anthropomorphic features (Goodall 1944). This shows that fertility symbolism was an integral part of iron production in eastern Zimbabwe as elsewhere on the plateau, as decorated furnaces have also been recovered by Bent (1892) and Ndoro (1991) near Great Zimbabwe and by Cooke (1959) in the Matopos. Among the different sub-groups of the Shona in Zimbabwe and beyond, there was a symbolic association between iron smelting and human reproduction. The iron smelting furnaces were metaphorically linked to a woman who was impregnated during smelting to give birth to iron. It is not surprising that Bernhard (1962) observed furnaces designed as women giving birth in Nyanga. The heat produced during smelting was analogous to the heat generated during copulation. The process of iron smelting was also ritualised; iron smelters were supposed to abstain from sexual intercourse with their real wives during smelting for it to be successful. However, such rituals were not universally applicable as seen in Chapter 4 with the Njanja case.

One of the areas that have generated academic controversy over the last twenty years or so is the spatiality of iron smelting in relation to settlement areas. It has been argued that because of the link with human reproduction which is a private activity, iron smelting was therefore practised in secluded areas where it could not be observed by non-smelters. Archaeologically, most furnaces were located in isolated places such as Cooke's (1959) furnace and those observed by Bent (1892) prompting some researchers to generalise that iron smelting during the entire Iron Age was practised in isolation and away from settlements (Herbert 1993, Huffman 1996).

Apparently, such generalised interpretations contain assumptions which must be challenged. This is because they project the picture of a static past by arguing that iron smelting amongst all societies throughout the Iron Age was located outside settlements. As shown in Chapter 4, there was variation in the location of iron smelting episodes in the 19th century with the Njanja who used gendered furnaces situating their furnaces in the villages with women's labour playing an important part. Similarly in Nyanga, some of the furnaces with the most explicit sexual decorations such as the one at Upper Pungwe were located close to pit structures believed to have been used as houses (Soper 2002). What is even more interesting is the fact the most of the Nyanga smelting furnaces were located in low stone walled enclosures, a practice that has not been recorded anywhere in Zimbabwe which further shows variation in practices of iron smelting at inter-regional and inter-cultural levels.

The other issue to seriously consider is the fact that fertility symbolism was also expressed on many items used in both public and private spheres. In this connection, items of material culture such as drums, clothing, clay pots and granaries which were used in the public areas were decorated with breasts and other motifs that appear on furnaces (**see Figs 5, 7, and 66**) showing reproductive metaphors were expressed at every level by the Shona and may not have been important in deciding the location of furnaces as frequently argued. This seems to suggest that ritual practices associating smelting with gendered principles persisted but the spatial location of smelting activities may have shifted.

Figure 66 shows that fertility symbolism was expressed on items of material culture used in public and private domains



A study of the spatial organisation of iron working in relation to settlement areas throughout the Iron Age reveals important variations that strongly warn archaeologists of using generalised models to explain every situation in the past. The evidence from Swart Village shows that iron was smelted within settlements. This is well supported by the recovery of furnace and flow slag in similar contexts with pole impressed architectural remains. The practice of iron smelting within villages was also documented at other EIA sites such as Kadzi (Pwiti 1996), Surtic Farm (Prendergast 1983) and Kwali (Swan pers. com). This shows discontinuity in spatial organisation between the EIA communities with some later ones, particularly those documented by Bent (1892).

In the LIA major variations exist in the spatial location of iron smelting. For example, researchers who have worked at Great Zimbabwe since the turn of the 19^{th} century have found evidence of iron smelting at the site (Hall 1910, Caton-Thompson 1931, Collett *et al.* 1992). In line with this pattern of smelting within habitation areas, evidence of iron smelting was also documented at Tere and Baranda, sites which belong to the Zimbabwe tradition. This accumulation of cases in which smelting seems to be located in villages is now compelling suggesting that smelting was indeed practised within villages even at sites where no excavations have been done. In this connection, models that argued for the spatial separation of smelting from settlement areas throughout the Iron Age promote a static and stereotypical view of African technologies and societies. They must be rejected in favour of those that take into account variation through time.

Conclusion

While the bloomery process was utilised throughout the entire Iron Age period in Zimbabwe there were important technological modifications that make it possible to distinguish iron smelting in the EIA from that of the LIA period. There was variation in the practices of iron working at inter-site and inter-regional levels which derived from technological choices adopted as smelters engaged with the world around them to produce iron. Iron smelting at Swart Village was different from that practised by smelters at Baranda. While large furnaces which utilised large tuyeres and were possibly natural draught driven were used at Swart Village, very thin and small tuyeres typical of small bellows driven furnaces were used at Baranda. The manganese rich ore used at both sites was almost identical in terms of its elemental composition. However, smelters at Baranda and Swart Village responded with different technological choices to it. The large furnaces from Swart Village produced mostly tap slag while furnace slag dominated the slag produced at Baranda. It seems that the furnaces used in the EIA were generally large, as Mackenzie (1974b) and Prendergast (1983) have proposed. Such furnaces clearly contrast with the small low shaft furnaces that became widely used from the 15th century onwards at Baranda, Chisvingo (Prendergast 1979a), and in Chivi (Robinson 1961).

These large EIA furnaces can also be separated from the furnaces that were used at Wedza and Nyanga from the 18th century. These furnaces are small belonging to the typical Shona furnaces which possessed rake holes for removing slag and the bloom. Noteworthy is the fact that iron smelting at Baranda is also distinct from that used in Nyanga and Wedza. Between them, Nyanga and Wedza were very different with Njanja furnaces utilising between four and six tuyeres while between two and three tuyeres were used by Nyanga smelters, showing that there was variation even within the later period.

While there is variation due to different geologies in different regions, the technologies used at the sites studied also differed greatly in terms of their efficiency. This reflects on differences in the levels of skill, professionalism and organisation of technology. Of all the studied groups, Njanja smelting stands out as the most advanced in terms of organisation and the recovery of the metal from the ore. Njanja technology was modified in domains such as furnace air provision which facilitated slag metal separation and promoted the yield from their furnaces. The scale of Njanja production was also huge which contrasts with that at Baranda for example. Nyamurondo village is also very efficient when compared with other Nyanga sites despite utilising a related ore. When considered from a chronological stand point, it is apparent that over time smelters made technical and organisational improvements which distinguish later from early smelting practices.

If the technology was not static over time as demonstrated above, so neither was its spatial organisation. The Njanja and Nyanga cases have shown that iron was smelted near homesteads where access to resources such as labour was important. By smelting in Wedza and selling their products on the way home, the Njanja case also shows that economics (demand) also played a part in the location of smelting episodes. Furthermore, the reproductive symbolism and rituals that in the past have been argued to be the major determinants of the location of iron smelting were expressed on every level of society suggesting that their importance may have been over-emphasised. That smelting was conducted in villages at Swart Village and other early sites suggests variation between the early and later periods. Quite clearly, on every level, there are variations and continuities in iron production in Iron Age Zimbabwe demonstrating the need to consider individual rather than generalised histories of technology.

When considered in light of the above information, it becomes clear that most of the issues raised at the beginning of this study have been resolved. The changing patterns of iron production in the Iron Age of Zimbabwe have been shown by major and diachronic differences in the practices of iron smelting documented at Swart Village, Baranda, Nyanga and Wedza. Even though natural factors such as geology played a role in the variation, human agency was more important. The decision to use large furnaces which were possibly powered by natural draft and slag tapping at Swart Village was a technological choice which enabled smelters to meet their iron requirements. When confronted with a similar ore, smelters at Baranda used small furnaces which were bellows driven. Equally, technical and organisational improvements enabled the Njanja to develop a market oriented economy. Just as the technology was changing, so was its spatial organisation over time. Different communities sited their furnaces at different locations determined by the location of important resources. Thus even if reproductive symbolism and rituals were associated with iron working in the later period, they did not universally dictate the location of production episodes showing that the ideas of a static African iron working are no longer sustainable. More importantly, this study is one of the first works to close the geographical gap in the understanding of ferro-metallurgy in southern Africa between the works of Haaland, Killick, Mapunda, Schmidt and colleagues in Tanzania, Kenya and Malawi to the north and Miller, van der Merwe and others to the south (see Chapter 2). The metallurgical work has identified two major stages in the *chaîne opératoire* of iron working and these are smelting and primary smithing. However, the intricacies of the smithing of objects have not been studied owing to the failure to find finished objects at the studied sites. The last Chapter summarises the results of this work against a background of earlier work which was unconnected and isolated, at the same time placing iron working in Zimbabwe in its regional context.

Chapter Nine: Conclusions: a broader view of iron production in pre-colonial Zimbabwe and beyond

"Attention to the broad sweep of historically specific circumstances does not easily accommodate itself to formal generalisable mathematical models" Adams 1996, p. 13)

Introduction: a story of continuity and change

This chapter seeks to draw some conclusions on the production of iron in Iron Age Zimbabwe within the context of the available data and the limited nature of the evidence. In the process, it connects previously unrelated works and integrates them within the studies carried out in northern and eastern Zimbabwe. Such an endeavour has produced important information on which to model the development of iron working and its role in society thereby providing a broad social, political and economic framework for understanding iron production and use. Whilst there is some stability in iron working through history, particularly in the adherence to the direct method, the craft was progressive; reacting to local and external stimuli as well as interacting with other aspects of society contributing to change. As shown in the previous chapters, a diachronic analysis of iron working in various regions and cultural periods shows that the industry was not stagnant once adopted. Instead, it developed locally as demonstrated by the glaring changes in furnace and tuyere sizes (Swart Village and Baranda), methods of operating and blowing the furnaces (early natural draught furnaces and later furnaces which were bellows driven), scale of production, improvements in the organisation of technology (historical Njanja) and even in the spatial organization of the craft (Kalanga of Matopos and the later part of the Nyanga Complex). Apparently, succeeding generations made some changes to the technology while retaining some practices from earlier periods. In these cases as well as elsewhere on the Zimbabwe plateau and adjacent territories, the socio-cultural context of iron working also transformed as broader society developed and achieved greater complexity and social differentiation. This issue of the development of iron working technologies is of considerable significance to archaeologists and archaeometallurgists for the much more differentiated light it sheds on the technology, social organisation, and symbolism of early metalworking in southern Africa and beyond. Significantly, this contrasts with the negative ethnocentric perspectives which tacitly assumed that African iron working was stagnant since its introduction to the continent. Using the evidence from archaeology, ethnography and archaeometallurgy presented in this study, such biased suppositions are therefore dismissed here as invalid and not sustained by the evidence. Thus, the image of a timeless iron working far removed from society must be replaced by one which perceives the technology as an innovative process as well as a significant social component which mingled and amalgamated with factors such as economics and politics to mould many African societies through time.

Iron technology in the Iron Age: a view through time

Based on the laboratory analyses conducted and the information obtained from the NASD and published documents, it is clear that there was continuity ***and*** change in the technology of iron working in the Iron Age of Zimbabwe. Although iron working practices were expressed differently through time, there is no doubt that smelters thrived on exploiting high grade ores of a wide variety. Such ores could be obtained locally as in the case of Surtic Farm and Nenga or at a distance as we have seen for the Njanja. It is possible that the composition of certain ore types may have influenced the development of regionally distinct smelting techniques. For example, the Njanja have historically been associated with the Wedza ore even though it was located at a considerable distance to their settlements. This also shows that they had systematically mastered its behaviour in the furnaces. With the ubiquitous nature of iron ores, it is possible that some were available near their homeland but their technology became inextricable from the Wedza ore. This point is further reinforced by the fact that the re-enactment of iron smelting using the high grade magnetite ore from Buchwa failed to produce iron by Karanga bowl furnaces used in Shurugwi (Prendergast 1972). Prendergast rightly argues that one of the reasons why the smelt failed was that the smelters were used to the haematite from Lalapanzi which their technology was adapted to. It is highly likely that if the Shurugwi smelters had had more encounters with the Buchwa ore, they would have developed methods to smelt it. Elsewhere in southern Africa, the development of a smelting tradition of adding sand to act as flux in reducing the high grade ores at Phalaborwa is also another example of local factors influencing innovation and the nature of technologies.

There appear to be a technological tradition in the later Early Iron Age of northern Zimbabwe which possibly utilised large furnaces and tuyeres and produced large blocks of fluid slag from the furnaces. Such a tradition contrasted with that documented in southeastern Zimbabwe at sites such as Kwali as will be discussed below. The large blocks of slag found at Swart Village which had clearly defined flow structures typical of tap slag have not yet been encountered in other areas of the country. As shown by the evidence from Swart Village and Surtic Farm, there is a possibility that slag tapping may have been practised in this early period. This existence of slag tapping in the terminal EIA of northern Zimbabwe is of considerable interest because it has not been documented in the succeeding Late Iron Age period. Obviously, there is the need to study more sites dating to this period to understand fully the distribution of this technological trait and in particular to locate furnaces which demonstrate that tapping existed. Since technologies are always mobile and change with the emergence of new groups of people, it is possible that slag tapping was discontinued with the advent of the Zimbabwe Culture in the area which has been linked with the low shaft furnaces. Alternatively, this may not have been formal slag tapping, but smelting that produces heavy runs of slag for yet unknown reasons. Noteworthy in this period is the fact that there are differences in the scale of iron production at the different sites in northern Zimbabwe which point to the centralised control of the industry at some sites. For example, while Swart Village has large scale evidence of iron working, production at contemporary sites in the area such as Matanda Farm and Madzinga Farm seem to have been small scale. Similarly, the site of Surtic Farm also possesses evidence of large scale iron working which is in contrast to the other sites in the region. This possibly points to the evolution of centralised areas of production which catered not only for local but also for external markets, leading to specialisation and social stratification within and between groups.

In south-eastern Zimbabwe, EIA smelters at sites such as Kwali made their tuyeres differently from those found in the north (as discussed in Chapter 3). Almost all of the tuyeres recovered from the site have striated finger impressions that are reminiscent of tuyeres used in northern South Africa (Klapwiyk 1986) in the same period. In southern Zimbabwe, the LIA site of Nenga (AD 1200) (discussed in Chapter 3) has yielded striated tuyeres such as those recovered from Kwali. Clearly, this contrasts with the tuyeres documented in northern Zimbabwe in the same period, suggesting the existence of separate groups of people and metallurgical traditions. This clearly shows regional diversification and variation in technology through time.

The discovery of the earliest known natural draught furnace south of the Zambezi by Prendergast (1975) (see Chapter 3) throws some interesting light on the changing patterns of iron production in the Zimbabwean metallurgical past. These natural draught furnaces from the Darwendale area (dated to the 14th century AD) contrast with many furnaces that were used in the Early Iron Age at sites such as Kwali and those used in the historical period that were bellows driven. The furnaces found in the Darwendale area have been associated with large concentrations of slags which led Prendergast to suggest that the production of iron in the area was market oriented. Not much is known about the distribution and origin of these natural draught furnaces in Zimbabwe and it is hoped that future research will engage this issue. The northern part of Zimbabwe has seen the influx of different groups of people from central Africa in the course of history and these may have brought their technologies with them at one point or another. This issue of natural draught furnaces has further been complicated by the discovery of a similar furnace near Great Zimbabwe by Ndoro (1994) dated to the 17th century. According to Ndoro, this furnace has no parallel in the area indicating that it may have been introduced by itinerant smiths from regions that were using such furnaces in the period. This is plausible in view of the fact that most trading groups carried their technologies with them. It is in this way that the Njanja are alleged to have brought their advanced techniques into the central plateau area (Mackenzie 1975).

The available evidence suggests that the use of natural draught furnaces in northern Zimbabwe did not go beyond the fifteenth century AD. Why were natural draught furnaces abandoned when they seem to be in widespread use in areas such as Central

Zambia in the second half of the second millennium AD? The existing evidence shows that the advent of the Zimbabwe culture in the Darwendale area (from the south – Great Zimbabwe) coincided with the appearance of low shaft furnaces that have been linked with the Shona speakers. Whether the makers of the natural draught furnaces were absorbed by these new groups or migrated from the area remain possibilities which are unproven as yet. From a functional viewpoint, the low shaft furnaces may have been more efficient in terms of charcoal consumption and the amount of time needed to produce iron (Gordon and Killick 1993, Haaland 1985, Killick 1991b) thus releasing labour for other activities.

From the middle of the second millennium AD onwards, the low shaft furnace seem to be the dominant or only furnace type used on the Zimbabwe plateau. Such furnaces were clearly bellows driven. It has been assumed that the failure to retrieve pots that could have been used as bellows implies that they used bag bellows (Mackenzie 1974b). These low shaft furnaces are similar to the ones recorded by Prendergast (1979) at Chisvingo, and by Pikirayi (1993) at Baranda and Chenguruve Hill. Bernhard (1962) observed similar furnaces in Nyanga, north-eastern Zimbabwe. In southern and western Zimbabwe, similar furnaces were found by Robinson (1961) in Chivi and in the Matopos by Cooke (1959). There is no doubt that the furnaces are distributed in the Shona areas and also show their influence on the plateau since the second half of the second millennium AD. While these Shona furnaces dominated for close to four centuries, there were some modifications that can be noted during that period. The case of the Njanja springs to mind because while exhibiting the characteristics of the other low shaft furnaces, their furnaces had technological modifications which made them more efficient than that of their contemporaries and predecessors alike. The Njanja furnaces used between four and six tuyeres with two to three pairs of bellows which greatly improved the output from their furnaces. As shown in the slag chemistry (more efficient use of ore), this made their furnaces more efficient in the reduction process than any iron smelting process documented in the Zimbabwean past so far. Furthermore, with time the Njanja organised their production along industrial lines operating up to twenty furnaces at a time. Apart from being large scale, the Njanja industry was a semi-continuous process that employed a shift system of labour. This made it easy for them to satisfy the demands of their ever increasing market showing that when organised differently, a similar technology can produce different results. There is no doubt that when colonisation began, the Njanja were well ahead of their contemporaries in terms of organisational ability and skill in metal working. When viewed diachronically, this demonstrates that though there is continuity in the bloomery production of iron, it was modified and organised differently through the course of history with different efficiency and effectiveness.

It seems that the process of primary smithing was stable throughout the Iron Age period. The basic tools of the smith's workshop comprised of hammerstones and anvils usually of hard rocks such as granites. It is possible that the smithing structures also changed with time as the furnaces did though we have no way of verifying this. With this apparent similarity in tools, the next question to ask is whether the metal fabrication methods also changed or remained the same. Obviously that question cannot be answered on the basis of this study due to the failure to retrieve finished objects. Childs (1991d) has shown that the fabrication methods were relatively stable in the LIA period. This view is supported by Miller's (2002) work on metal objects from sites scattered across southern Africa including Great Zimbabwe which showed that there was little variation in iron fabrication methods in the Early and Late Iron Age. With more research in the future, it is hoped that fabrication methods in the Iron Age of Zimbabwe will be fully understood.

Continuity or discontinuity: the role of technology in society and the spatiality of iron production in the Iron Age

"...although every technology has its physical and intellectual components that we can study separately, it should be regarded foremost as a social product" Holl (2000, p.21)

The material traces of iron working are rare in the early centuries AD, only becoming more abundant towards the end of the first millennium AD as settlements became larger. This observation is supported by the recovery of large Early Iron Age village sites with copious evidence of iron working from AD 800 onwards. In most of the first millennium AD therefore, iron seems to have been a rare and valued metal that contributed towards societal developments. Using a model based on the work of Flannery and Marcus (1993) and Flannery (1999), Pwiti (2005) argued that a shift from an ideology that emphasised equality to one which encouraged the accumulation of wealth led to the control of productive sectors of the societies such as iron working and trade by certain individuals (see also Pwiti 1996, p. 166). As a fairly new technology, the production of iron was associated with the beginning of craft specialization, a form of social division of labour that played a major role in the emergence of ranked societies (Costin 2001, Hayden 2001, Kiyaga-Mulindwa 1993). Leading smelters and smiths controlled the production and distribution of iron which placed them at the nexus of socio-political events and also enabled them to dominate others. In this way the newly established elites controlled the proceeds from trading iron implements and other objects and used them as a springboard to political power. With time, this elite control of production led to the rise of "big men" who exploited their leading role in society to exert their control over others. Subsequently, these societal transformations led to the development of complex societies of the late first millennium AD at sites such as Swart Village and Kadzi. This elite control of iron working is well supported by the changes observable in the archaeological record from the end of the first millennium AD to the early second millennium AD.

During this period there is evidence of the development of large village settlements which span several hectares in northern Zimbabwe as well as in the Shashi-Limpopo basin. These villages such as Kadzi, Swart Village and Surtic Farm have concentrated evidence of human occupation, worked ivory and glass beads. Glass beads and ivory which are status goods would implicate these sites as having been dominated by some influential individuals in society who also controlled iron production. On a regional perspective, the scale of iron production at some of these village sites is greater than that discernible at contemporary sites which are also smaller demonstrating the elite control over commodity production during this period. As discussed in Chapter Five, the scale of iron production at Swart Village is by far greater than that at contemporary sites in the Mt Darwin area such as Matanda and Madzinga Farm sites. This trend of control of commodity production along a political gradient is also attested in the mid-Zambezi valley more than eighty kilometres west of Mt Darwin. In this region, a political centre seems to have developed at Kadzi as demonstrated by the concentrated remains of pottery, shell and glass beads, worked ivory and iron slag. This richness in material culture is in stark contrast with the picture observable at contemporary sites which lie within a two kilometre radius from the site such as Chigu and Kamukombe. Again, the scale of iron working is more intensive at Kadzi than it is at these other satellite sites. As part of male dominated craft production, there is no doubt that the control over an important technology such as iron working enhanced and promoted the fortunes and ambitions of leading figures who dominated the large village settlements that emerge in northern Zimbabwe. There is a possibility that iron produced at the large village sites was also traded with the Indian Ocean from around AD 1000 onwards and there is no doubt that such trade introduced new forms of wealth which aggregated with local factors leading to the emergence of class differentiation and complexity on the Zimbabwe plateau. It is therefore not surprising that as an important sector of the economy, iron working was located within the centre of villages where the elites lived.

Similar developments have been noted elsewhere in southern Africa, including Botswana, KwaZulu-Natal, South Africa and the DRC. For instance, this trend toward elite control of the productive economy and ritual has been documented at Zhizo sites (terminal EIA sites) in the Shashi-Limpopo valley (Calabrese 2000). It has been argued that the senior individuals at sites such as Schroda exerted their control on commodity production and control of trade which led to the emergence of hierarchically organised societies. As part of the economy, there is no doubt that control over iron working documented at the sites contributed to this rise and intensification of political centralisation. Kiyaga-Mulindwa (1993) has suggested the existence of similar societal transformation processes in the growth of complex societies at the Zhizo sites in the Tswapong area of Botswana in the later part of the Early Iron Age. He argued that the specialization that is frequently linked with iron working led to the emergence of powerful individuals who controlled the allocation of critical resources leading to the rise of "big men" societies and even chiefdoms. Similarly, Whitelaw (1994) has demonstrated that control over iron production amalgamated with other factors such as control of ritual leading to the beginning of political hierarchies in the EIA of KwaZulu-Natal, South Africa. In this region, there is evidence of elite control of production as shown by the recovery of objects such as ivory at KwaGandaganda and the accumulation of debris such as pottery and iron slag which was consistent with centres of power as opposed to commoners' villages. Based on the artefactual evidence from Kisalian sites in the Upemba Depression of the DRC, de Maret (1985, pp.78-79) maintains the view that the development of complexity took place within the later part of the Early Iron Age with iron production playing a crucial role. The recovery of expressive iron objects from the wealthiest graves in the Upemba Depression is indicative of the connection between iron working and royalty in this early period. This shows that new statuses and social roles were associated with the development of iron working. Thus when conceived in the above light, it becomes clear that control over commodity production including iron working was a powerful stimulus of the development of complexity in all parts of southern Africa, Zimbabwe being no exception.

By the middle of the second millennium AD, iron was very common and entrenched in every aspect of society. The emergence of state systems in the early part of the second millennium AD at Mapungubwe and subsequently at Great Zimbabwe and its successor states is linked with a change in the social role of iron working. This same period has also seen an increase in population which was matched by an upsurge in the exploitation of iron (Sinclair 1984). In view of the agrarian base of the economies of LIA peoples, there is no doubt that iron tools were essential in cultivation purposes. A good example is the Nyanga Agricultural Complex which emerged around the 13th century AD in north-eastern Zimbabwe. This intensified farming complex has been associated with widespread evidence of iron working showing the importance of the metal in such societies. This use of iron tools in agricultural production has also been attested at the Leopard's Kopje Main Kraal site in south-western Zimbabwe. Robinson (1959), recovered finds of millets and iron tools such as hoes which may have been used for agricultural production. Also, iron tools such as gads were also used in other branches of the economies such as gold mining which further underscores the importance of the metal in virtually all societal economic activities.

Iron was very important in the conquest states that emerged in the second millennium AD such as the one based at Great Zimbabwe and its successors the Mutapa and Torwa-Changamire polities. The fact that these states controlled vast tracts of territory meant that they had considerable iron requirements for making weapons such as spears for territorial expansion and consolidation. It has been suggested that the production of iron at sites such as Great Zimbabwe was under royal control as shown by the recovery of iron furnaces and a large hoard of iron hoes from the site (Herbert 1996). However, the small scale production of iron witnessed at the site and the large concentration of finished iron objects implies that most of the iron requirements would have been met by other means such as levying tribute, as was the case with its successors, the Mutapa and Torwa-Changamire states. Portuguese documents have shown that successive Mutapa kings collected iron hoes as tribute from their vassals (Abraham 1959, Mackenzie 1975). Such iron objects were then used for making weapons, agricultural tools and even traded with the Portuguese. This possibly explains why the scale of iron production at Mutapa centres of power such as Baranda and Zvongombe was very small and probably only a symbol of royal control over the production and distribution of iron in the state. The mighty Changamire army, which is credited with expelling the Portuguese from the plateau area, had considerable iron requirements which may have also been met by levying tributary states. Similarly, the

19th century Ndebele state relied on tribute from their vassals to satiate their iron requirements. They left conquered Kalanga smiths to pursue their crafts in the areas close to their capital at Old Bulawayo and this gave the Ndebele access to iron which was essential for the success of their armies in battle. The absence of concentrated remains of iron working in the vicinity of former state capitals such as those mentioned above has been used as evidence of ritual seclusion of iron smelting from living areas. However, the existence of small scale iron smelting at state capitals such as Great Zimbabwe and Baranda would imply that the iron requirements were met by the subjects of the state. This also could indicate that iron was no longer so special as in earlier periods, and its production no longer the basis of power; instead, those who had power could now demand iron production. Thus the emergence of stratified societies may have been based on iron but their maintenance no longer was once they were established. This sequence would have occurred at different times in different regions, and possibly more often than just once. There is no doubt that powerful rulers such as the Mutapas had adequate resources to ensure compliance from their vassals and indeed several wars were fought to ensure that some provinces paid their dues to the king's court (Beach 1980).

During the Late Iron Age, there is increasing evidence that iron objects were used as symbols of power and as ceremonial objects at different levels of society from the commoners to the royal centres of authority. It is possible that the expressive objects recovered at commoner sites may have been used for family ancestors whilst those from state capitals such as Great Zimbabwe and Khami would have been important in ritual and power dynamics of the state. As such, a wide variety of ceremonial objects and royal insignia such as spears and axes have been recovered at capitals such as Great Zimbabwe (Caton-Thompson 1931), Khami (Robinson 1959), Zvongombe

(Pwiti 1996) and Mt Muozi (Soper 2002). In this latter period, in addition to being used as symbols of power, iron objects such as hoes were also used as payment for bride wealth, an institution which we do not know how deep in time it extends. Thus in contrast to the EIA where elites controlled the actual production, for most of the states of the second millennium AD, the control of production may have been symbolic. This is plausible in view of the fact that none of the large scale iron production documented at sites such as Swart Village has been documented at any of the later sites except the Njanja who had not achieved a state level of organisation. Instead, it seems that most of the elites in the LIA controlled the distribution of finished products. For most historical states in Zimbabwe, there is no king smiths relationship as was the case with central and eastern African states such as the Luba and Karagwe. The only notable exception as mentioned before is the case of the Njanja whose chiefs were men who were famed for their iron working prowess. However, their chiefdoms were very small territorially when compared to the Mutapa, Torwa-Changamire or Ndebele states, their success being more economical than political.

Another interesting aspect observable in the later period of Zimbabwean archaeology is the apparent connection between human reproduction and iron smelting. Some of the furnaces encountered by late 19th century observers and those discovered by archaeologists in the course of the 20th century were gendered, as they were designed as sitting women with breasts, navels and in some cases genitalia. Such furnaces with explicit decorations of human features have been recovered archaeologically for example by Ndoro (1991) and by Soper (2002). Because of its association with child birth and human copulation which were private activities, iron smelting in some historic societies was practised in seclusion from settlement areas. Bent (1892) actually recorded cases in which iron was smelted in isolated areas in Chivi as well as at Kunzvi's kraal near Harare. A closer look at the available evidence has revealed a great deal of variation regarding the spatiality of iron smelting even within the historical period. As we have seen, the Njanja furnaces were gendered just as their other categories of material culture were, but the location of their iron smelting areas was mostly dictated by the location of vital resources such as labour.

In eastern Zimbabwe, the Nyanga complex area has produced iron smelting furnaces with breasts, navels and even genitalia as shown in Chapter Six. Again, some of these furnaces were located close to habitation areas while others were adjacent to cultivation ridges and terraces. The Nyanga case is interesting because of the fact that these furnaces were located in low stone enclosures which hardly concealed the smelters from the non-smelters. While these enclosures have been seen as a form of ritual seclusion, they were also probably built to protect the furnace when not in use or even to keep out animals. It is therefore apparent that the spatial organisation of iron smelting in relation to habitation areas varied from society to society even within the historical period. In fact for most societies on the plateau, the metaphors of human reproduction also appeared on other items of material culture such as pots, granaries and drums that were used in public places and thus show that fertility symbolism was part of the people's cosmology which did not dictate the location of iron working in every historical case as we have been made to believe.

One of the issues that have generated academic interest over the years is whether the spatial separation of iron smelting and settlement areas observed in some 19^{th} century societies was of deep antiquity or not. Starting with the Late Iron Age, most of the evidence point to the fact that iron was smelted within the centre of villages. As seen at Baranda which is also a Zimbabwe tradition site, iron was smelted in contexts with house foundations and domestic debris showing that it was part and parcel of the human activities at the site. Also, the finds of iron slag and collapsed furnaces recovered from Great Zimbabwe since the late 19th century and more recently by Collett *et al.* (1992) shows that iron was indeed smelted at the site. As I have argued before, the lack of concentrated remains may also indicate that the royals controlled the distribution of finished objects rather than the production as was the case in the EIA. This trend of the practice of smelting at settlement areas has also been attested at sites such as Chivowa Hill, Leopard's Kopje, and Gumanye which are believed to be forerunners of the Zimbabwe tradition. Sinclair (1984) found iron smelting debris at Chivowa Hill and argued that iron production was a major branch of the economy at the site. Thus in as much as there are some sites which demonstrate the spatial separation of smelting from habitation areas, these examples clearly show that such a spatial configuration did not apply to every case. Paying particular attention to each and every case shows that it is difficult to make universal interpretations on the basis of selected ethnographic observations as there was variability even within the ethnographic record as shown in Chapter Four.

Turning to the EIA, it has been argued that due to a similar spatial code or settlement pattern emanating from a related cosmology, iron smelting amongst the first millennium AD communities also took place in secluded/private places outside settlements as in the late 19th century (Huffman 1993, p. 221). Using the Early Iron Age site of Broederstroom as a case study, Huffman upholds that a similar smelting-outside and smithing-inside dichotomy existed as early as the first millennium AD. Furthermore, this spatial separation of iron smelting and living areas was part of a settlement pattern called the Central Cattle Pattern (Huffman 1986, 1996) that was practised since the EIA. He further argued that the iron extraction remains recovered from the site were from iron smithing and not smelting even if this observation was not supported by detailed laboratory observations. According to this interpretation, there was continuity in the spatial organisation of iron working from the EIA through the LIA to the historical period in southern Africa. A closer look at the available data from Zimbabwe shows that there appears to be no clear cut division of iron smelting and smithing areas during the Early Iron Age. As shown by the stratigraphic excavations at Swart Village, there is no temporal separation of smelting and smithing areas over time and in fact most of the evidence points to the dominance of iron smelting debris. Pwiti (1996) made similar observations at Kadzi even though the Central Cattle Pattern may have been practiced at the site. Other sites such as Kwali have also produced iron smelting slag and broken tuyeres in similar contexts with house remains and pottery. Clearly, this is different from those 19th century societies that practised the ritual seclusion of iron smelting and this probably points to variability in the spatiality of iron working in both the early and later periods.

It seems that the Zimbabwean Early Iron Age sites are not unique in producing evidence of iron smelting in residential areas, for other sites in the region have done that as well. For example, Haaland (1993) observed that Dakawa, an Early Iron Age site in Tanzania was simultaneously a habitation site and a place for smelting iron which led her to question Huffman's rather static and monolithic settlement model. Similarly, Whitelaw (1994) posited that iron smelting during the Early Iron Age in Natal took place within the settlements. This position is also supported by Fagan (1965) whose work in southern Zambia unearthed several EIA sites with iron smelting at the centre. The major weakness of the theory of continuity in spatial organisation of iron smelting and settlement areas is that it is supported by a settlement model which tacitly assumes that late 19th century societies in southern Africa were primeval (Haaland 1993, Lane 1995, pp. 59-60, Pikirayi 2001). Theoretically, such a presumption is problematic because it views many southern African societies and their technologies as timeless, a view that has been shown to be at variance with reality. Thus such a model (Huffman 1996) sacrifices potential cultural changes for an inflexible settlement pattern thus promoting ideas of a moribund past. In fact it can be argued that instead of being static over time and being held back by ritual as believed by some researchers in the early 20th century, iron production during the Iron Age was permanently subject to continuities and changes necessitated by changing social and economic conditions through time.

Directions for future research

While this research has produced some important insights into the production of iron in Iron Age Zimbabwe, it cannot claim to be a final statement on the subject. Of course, one has to be aware of the limited nature of the evidence which has left some issues partially resolved. Clearly, the recovery of the sites has not been uniform for all regions and archaeological periods. In this regard, the failure to find sufficient evidence to reconstruct EIA furnaces has made it virtually impossible to fathom the nature and types of furnaces used in this period. In addition, that most of the sites studied so far are clustered in the period after AD 700 has meant that we know little about iron working in the preceding period. Equally, very few technological studies of slags from early Late Iron Age sites exist, limiting our knowledge of iron working during the period. Also, there is need for long term studies to produce a regional data base of iron working sites over time. There is no doubt that such work will provide a more complete technological history than provided here. The other issue of interest linked to this point is the fact that it is important to study the distribution of certain technological traits that were detected in the study such as the slag tapping and the natural draught furnace phenomena. Why were they abandoned when in some regions of the sub-continent they are seen as advances which separate later iron working traditions from previous ones? Also, should interpretations of iron working over time be limited by some archaeological models such as the Central Cattle Pattern? Surely, more research should show that the location of iron production episodes was more complex than the simplicity inherent in the smithing-inside smelting outside settlement dichotomy. Also, these studies of metal working residues must be complemented by analyses of excavated objects from several Iron Age sites to have a comprehensive picture of fabrication techniques over time. Only then can we have a detailed and fuller *chaîne opératoire* of iron working in Iron Age Zimbabwe.

Whilst change is integral to the technological past, at times the changes were often subtle and require very careful examination. This demonstrates the need to create good practices in dealing with metallurgical remains in Zimbabwe and beyond recognising technological change and innovation. It is therefore hoped that the following guidelines will help future research on iron production and its development through time by both archaeologists and archaeometallurgists.

1. There must be a systematic recovery and recording of the contexts in which slag and tuyeres are retrieved from. This contextual data is crucial in defining the stages in the *chaîne opératoire* represented by the suites of materials synchronically and diachronically.
2. Work should be targeted at furnace recovery and excavations to understand issues such as the existence of tapping holes and slag pits. It is very likely that

work of this kind will add more information on the distribution of furnace types such as natural draught driven and the distribution of traits such as slag tapping.

3. There must be targeted metallurgical studies aimed at accessing geological data which is crucial in identifying potential ore sources. Of course, for provenance studies to be meaningful, they must cover a wide area and a range of materials. Such an endeavour helps in understanding the role of natural constraints and the human factor in technological change and innovation.
4. More attention must be given to understanding smithing practices and fabrication techniques. It would be interesting to know if the modifications in the smelting technologies were matched by diachronic changes in fabricating technologies.
5. There is need for the integration of the work that has been done on gold and copper for example with that on iron working to understand how metals were used in society. As part of the same social fabric, there is no doubt that such an endeavour can contribute more towards the understanding of the changing values and evolving roles of these metals in society.

Admittedly, this study has been necessarily crude, but even so has demonstrated a rich and vibrant history of iron production. Indeed, it is hoped that future research will study pre-colonial iron production in Zimbabwe and beyond with some of the issues raised here in mind.

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Appendices

Appendix 1: Data Capture Sheet for Iron working remains from northern and eastern Zimbabwe

Category of remains

Slag

Description: its appearance, colour, magnetism, relative density, porosity
Type: tap or furnace slag
Dimensions/Metrical attributes: estimate of its size
Context i.e. surface or sub-surface
Relationship with other features and artefacts at the site

Ore

Description: general appearance, has it been roasted or not etc
Dimensions/Metrical attributes: estimate of its size
Type
Relationship to other features and artefacts at the site

Intact Furnaces

Description: its appearance, condition
Type: i.e. conical etc.
Decorations: are there any modifications like breasts etc.
No. of tuyere holes: give dimensions of those holes, height from the bottom of furnace
Context
Related and associated features

Collapsed Furnaces

Description: general appearance, firing, thickness,
Likely part: e.g. mouth, tuyere hole
Vitrification
Type of Furnace
Context
Related features and associated artifact

Broken tuyeres

Description: size, shape, firing
Dimensions: internal diameter, external diameter, length
Vitrification
Associated features and artifacts

Finished artifacts

Description
Type
Context
Associated and relationship with other features

Appendix 2

XRF Results from the studied sites

Swart Village

	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
Tap Slag											
SVT2 L2	0.57	2.10	6.88	22.60	0.24	1.42	2.76	0.24	11.00	53.02	100.50
SVT1 L1	0.41	2.21	5.06	21.80	0.28	0.97	1.93	0.17	10.52	60.84	104.19
STV1 L3	0.42	2.14	6.72	22.50	0.24	1.38	2.65	0.24	8.45	56.13	102.60
SVT2 L3	0.49	2.13	9.07	20.20	0.24	1.38	2.66	0.24	9.56	58.02	106.43
SVT2 L1	0.60	1.13	6.05	25.78	0.43	1.49	2.21	0.29	11.45	65.71	115.14
SVT2 L2	0.58	2.13	6.98	23.87	0.21	1.42	2.79	0.24	11.89	63.45	113.56
SVT2 L3	0.50	2.15	6.75	23.16	0.23	1.40	2.68	0.23	11.52	64.23	112.85
SVT4 L1	0.51	2.16	5.54	21.93	0.22	1.56	2.23	0.25	11.63	65.10	111.13
Average	0.51	2.02	6.63	22.73	0.26	1.38	2.47	0.23	10.75	60.81	108.30
Furnace Slag											
SVT3 L2	0.52	0.88	3.32	14.30	0.41	0.47	0.47	0.06	4.00	76.23	100.66
SVT1L3	0.07	1.71	3.34	18.90	0.09	0.67	0.89	0.08	5.20	74.64	105.50
SVT2 L2	0.21	0.87	3.01	22.30	0.48	0.32	0.71	0.10	6.20	69.36	103.30
SVT1 L1	0.57	2.36	4.89	19.07	0.23	1.31	2.01	0.11	9.86	70.96	111.37
SVT1 L2	0.62	2.21	5.76	23.79	0.88	1.23	2.93	0.22	3.67	65.63	106.94
SVT1 L3	0.68	2.09	5.34	18.71	0.18	1.01	1.79	0.12	5.23	76.05	111.20
SVT1 L3	0.71	2.33	4.98	18.02	0.24	0.62	1.34	0.09	4.54	80.19	113.06
Average	0.48	1.78	4.38	19.41	0.35	0.80	1.45	0.11	5.52	73.29	107.43
Smithing slag/Crown material											
SVT2 L2	0.44	1.84	5.27	20.60	0.11	0.86	2.22	0.15	7.00	71.96	109.90
SVT2 L3	0.28	0.84	7.26	16.30	0.35	0.49	0.14	0.06	3.90	76.44	106.06
SVT31 L3	0.73	2.18	8.16	17.50	0.21	0.65	1.47	0.09	4.80	70.63	106.42
SVT4 L2	0.47	2.56	6.67	19.80	0.61	0.73	0.93	0.15	4.10	68.23	104.25
SVT1L4	0.24	1.87	1.48	11.30	0.45	0.18	0.19	0.02	6.50	79.29	101.30
SVT2 L2	0.68	1.80	4.21	21.80	0.13	0.91	1.43	0.13	6.20	69.82	106.40
SVT3 L1	0.23	1.93	2.38	11.40	0.07	0.21	0.22	0.05	5.70	84.70	106.60
Average	0.44	1.86	5.06	16.95	0.27	0.57	0.94	0.09	5.46	74.43	105.85
Undiagnostic Slag											
SVT1 L2	0.64	2.08	6.13	24.30	0.90	1.47	3.01	0.21	6.71	59.67	105.12
SVT1 L3	0.76	2.28	6.06	22.50	0.81	1.67	2.04	0.18	5.31	69.20	110.81
SVT1 L1	0.70	1.66	4.84	17.30	0.20	0.61	1.53	0.13	10.00	65.23	102.20
Average	0.70	2.01	5.68	21.37	0.64	1.25	2.19	0.17	7.34	64.70	106.04
Furnace Wall											
SVT1 L4	1.24	0.89	22.80	55.80	0.25	1.37	0.92	0.52	0.00	4.75	87.26
SVT1 L2	2.35	1.78	22.40	58.00	0.29	1.52	0.22	0.53	0.10	5.18	89.92
SVT2 L3	2.43	1.26	20.20	68.40	0.13	2.06	0.77	0.72	0.10	5.58	101.65

Average	2.01	1.31	21.80	60.73	0.22	1.65	0.63	0.59	0.06	5.17	92.94
Tuyeres											
SVT1 L3	0.91	2.07	18.80	44.40	2.64	0.91	3.15	1.33	0.20	15.34	88.78
SVT2 L3	1.55	0.62	21.70	58.40	0.11	1.23	0.98	0.49	0.00	4.76	88.35
SVT2 L4	1.19	0.62	22.50	55.50	0.12	1.26	0.92	0.52	0.00	4.87	86.36
Average	1.22	1.10	21.00	52.77	0.97	1.13	1.68	0.78	0.06	8.32	87.83
Ores											
SVT2 L3	0.45	1.21	2.21	4.16	0.08	0.79	0.30	0.86	8.23	81.23	99.52
SVT2 L3	0.56	1.03	1.53	3.67	0.09	1.20	0.25	0.99	10.56	78.13	98.01
Average	0.51	1.12	1.87	3.94	0.09	0.10	0.28	0.93	9.39	79.68	98.77
SVT2 L2	0.39	0.89	17.67	53.46	0.09	0.42	0.31	0.51	3.67	15.81	93.22
SVT3 L2	0.47	0.99	18.89	55.35	0.10	0.65	0.26	0.76	11.87	10.07	99.41
Average	0.43	0.94	31.78	54.41	0.10	0.54	0.29	0.66	7.77	12.94	96.32
Ceramic materials											
SVTp1L4 Pol	0.99	2.00	20.47	45.23	0.38	1.17	2.80	1.25	0.01	14.66	88.95
SVTr2L2 Pol	1.12	1.92	19.34	47.15	0.23	0.93	3.02	1.27	0.01	14.18	89.17
SVTP1L3 P/D	2.35	1.79	22.35	57.96	0.30	1.52	0.23	0.54	0.01	5.12	92.16

Baranda

	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
Tap Slag											
BN T3 L4	0.61	2.18	6.16	25.20	0.82	1.48	3.06	0.23	2.30	62.84	104.90
BN T1 L2	0.35	0.77	7.63	19.90	0.38	0.61	0.75	0.13	6.80	63.76	101.08
BN T2 L1	0.51	1.96	8.32	28.45	0.51	0.85	2.16	0.19	2.76	65.89	111.60
BNT3 L4	0.65	1.30	7.39	24.40	0.61	1.00	1.19	0.18	6.27	66.07	109.05
BN T3 L1	0.61	0.67	3.94	19.45	0.62	1.13	0.29	0.06	4.41	76.97	108.14
BN T1 L2	0.20	0.76	4.87	24.98	0.05	0.56	0.61	0.13	6.85	67.06	106.07
Average	0.49	1.27	6.39	23.67	0.50	0.92	1.34	0.15	4.90	67.10	106.80
Furnace Slag											
BNT1L2	0.15	0.84	2.95	22.70	0.07	0.39	0.83	0.17	6.30	68.18	102.60
BNT2 L3	0.36	1.99	5.16	20.60	0.34	0.88	2.21	0.15	7.00	72.31	111.00
BN T2 L2	0.58	2.03	6.16	25.31	0.81	1.47	3.08	0.23	2.33	70.25	112.26
BNT1L1	0.06	0.82	3.42	12.92	0.30	0.61	0.74	0.14	6.41	78.48	103.90
BNT1L2	0.15	0.84	2.91	22.71	0.08	0.40	0.83	0.11	6.33	75.76	110.11
BNT2 L3	0.36	1.99	5.17	20.60	0.12	0.88	2.22	0.15	7.03	80.35	118.88
BN T3 L1	0.55	0.69	3.80	18.97	0.60	1.10	0.33	0.04	4.88	79.02	109.98
BN T3 L2	0.63	1.03	5.77	25.54	0.50	1.46	1.43	0.09	3.94	75.93	116.32
BN T3 L3	0.78	1.52	6.75	21.37	0.62	0.93	0.88	0.14	6.96	71.01	110.96
BN T1 L3	0.18	1.65	4.08	21.69	0.14	0.79	0.80	0.10	6.34	81.32	117.09
BN T1 L4	0.22	1.43	3.97	23.59	0.09	0.67	0.53	0.17	5.83	71.23	107.73
BN T3 L3	0.71	1.49	6.34	20.88	0.60	0.99	0.79	0.12	6.78	70.59	109.29
	0.39	1.36	4.71	21.39	0.36	0.88	1.22	0.13	5.84	74.53	110.84

Smithing slag											
BN T1 L3	0.51	0.79	3.28	13.70	0.08	0.64	0.39	0.04	7.40	73.29	100.10
BNT1L1	0.11	0.75	3.49	13.00	0.32	0.62	0.74	0.13	6.40	81.16	106.72
BNT1 L1	0.37	0.91	3.17	13.44	0.07	0.65	0.32	0.06	6.93	90.06	115.98
BN T3 L4	0.06	1.80	2.60	11.63	0.10	0.22	0.24	0.05	6.06	94.94	117.71
BN T3 L4	0.09	1.76	3.03	12.56	0.07	0.21	0.19	0.05	5.81	96.13	119.90
BN T1 L1	0.25	0.88	4.53	16.13	0.04	0.51	0.36	0.06	7.02	87.34	117.12
Average	0.23	1.15	3.35	13.41	0.11	0.46	0.37	0.07	6.60	87.15	112.92
Undiagnostic slag											
BN T3 L3	0.78	1.48	6.53	21.00	0.62	0.91	0.84	0.13	6.80	62.69	101.80
BNT3L4	0.54	1.36	7.46	24.40	0.61	0.99	1.17	0.18	6.20	59.27	102.20
BN T3 L3	0.82	1.04	6.13	20.40	0.83	0.89	0.75	0.12	6.00	67.55	104.53
Average	0.71	1.29	6.71	21.93	0.67	0.93	0.92	0.14	6.33	63.17	102.84
Furnace Wall											
BNT2 L2	1.39	0.83	16.50	72.00	0.01	2.29	1.38	0.63	0.00	4.40	99.52
BNT3 L4	0.69	0.98	18.30	63.60	0.46	3.83	4.68	0.39	0.00	4.02	96.95
BNT2L2	0.95	0.39	18.40	61.40	3.72	4.79	1.11	0.28	0.00	2.05	93.02
Average	1.01	0.73	17.73	65.67	1.40	3.64	2.39	0.43	0.00	3.49	96.47
Tuyeres											
BNT3 L2	0.91	0.27	24.20	60.30	3.03	2.43	0.67	0.25	0.00	2.56	94.62
BNT1L2	1.57	0.26	17.90	64.10	5.03	5.75	1.01	0.82	0.00	1.12	97.55
BNT1L3	1.59	1.69	23.60	53.10	3.99	1.88	1.62	0.71	0.00	5.82	94.00
Average	1.36	0.74	21.90	59.16	4.02	3.35	1.10	0.59	0.00	3.17	95.39
Ores											
BN T1 L3	0.20	1.56	2.86	6.43	0.05	0.06	0.86	0.79	8.97	75.27	97.05
BN T3 L3	0.60	0.98	3.13	5.12	0.06	0.06	0.92	0.67	7.92	78.13	97.59
Average	0.40	1.27	3.00	3.85	0.06	0.06	0.89	0.73	8.45	76.70	97.32
Ceramic materials											
BNT1L4 H/F	2.13	1.81	22.86	57.31	0.30	1.52	0.23	0.54	0.02	5.73	92.46
BNT3 L2 pot	0.92	0.29	23.67	59.39	3.01	2.37	0.68	0.25	0.01	2.48	93.06
BNT1L3 pot	1.27	1.82	19.51	59.53	4.00	1.55	2.14	0.61	0.03	5.09	95.55
Wedza	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
Tap lag											
W-Fs1	0.41	2.48	4.35	33.01	0.19	0.95	2.66	0.10	1.55	58.56	104.26
W-Fs2	0.44	1.21	5.21	28.82	0.35	1.21	3.39	0.11	1.84	59.78	102.36
W-Fs3	0.21	1.52	5.37	32.86	0.23	1.24	3.40	0.14	1.38	55.86	102.21
W-Fs9	0.48	2.29	4.16	31.86	0.19	0.94	2.61	0.10	1.49	57.85	101.97
W-Fs2	0.44	1.21	5.21	28.82	0.35	1.21	3.39	0.11	1.84	59.79	102.37
W-Fs3	0.21	1.52	5.37	32.86	0.23	1.24	3.40	0.14	1.38	55.86	102.21
W-Fs1	0.41	2.48	4.35	33.01	0.19	0.95	2.66	0.10	1.55	58.09	103.79

W-Fs6	0.27	1.54	5.12	31.13	0.28	1.09	3.16	0.14	1.29	60.61	104.63
W-Fs2	0.57	1.11	4.97	32.06	0.58	2.46	2.22	0.07	0.45	56.73	101.22
Average	0.38	1.70	4.90	31.60	0.28	1.25	2.99	0.37	1.42	58.12	102.78
Furnace Slag											
W-Fs4	0.38	0.44	5.20	24.50	0.33	1.15	3.23	0.10	2.16	65.48	102.97
W-Fs5	0.11	0.46	3.99	18.01	0.70	0.97	0.77	0.17	0.08	76.37	101.63
W-Fs6	0.27	1.54	5.12	31.13	0.28	1.09	3.16	0.14	1.29	56.61	100.63
W-Fs7	0.26	0.49	4.79	20.22	0.59	1.51	3.32	0.09	2.08	73.89	107.24
W-Fs8	0.36	1.21	5.50	29.23	0.45	1.23	3.44	0.11	1.87	61.28	104.68
W-Fs9	0.48	2.29	4.16	31.86	0.19	0.94	2.61	0.10	1.49	66.85	110.97
W-Fs4	0.38	0.44	5.20	24.50	0.33	1.15	3.23	0.10	2.16	65.48	102.97
Average	0.32	0.98	4.85	25.64	0.41	1.15	2.82	0.12	1.59	66.56	104.44
Smithing Slag/Crown Material											
W-Cr1	0.11	0.46	3.99	18.01	0.70	0.97	0.77	0.17	0.08	76.36	101.62
W-Cr2	0.26	0.49	4.79	20.22	0.59	1.51	3.32	0.09	2.08	73.89	107.24
W-sm3	0.34	0.50	3.52	13.49	0.27	1.24	0.66	0.10	0.24	85.29	105.65
W-sm1	0.25	0.19	3.96	14.93	0.84	0.62	0.34	0.19	0.06	84.10	105.48
W-sm2	0.22	0.54	4.24	19.05	0.75	0.96	0.76	0.17	0.09	87.60	114.38
Average	0.23	0.43	4.10	17.14	0.63	1.06	1.17	0.14	0.51	81.45	106.87
Undiagnostic Slag											
W-T1	0.32	0.48	4.71	22.88	0.32	1.05	3.14	0.09	2.33	71.66	106.98
W-Fs16	0.23	0.16	3.65	14.56	0.77	0.52	0.30	0.20	0.06	86.71	107.16
Average	0.28	0.32	4.18	18.72	0.56	0.79	1.72	0.15	1.20	79.18	107.07
Technical ceramics											
W-Tuy 1	0.61	0.13	20.95	61.41	0.00	0.05	2.18	0.55	0.04	6.67	92.59
W-Tuy 2	0.67	0.14	19.93	58.22	0.00	0.02	2.27	0.49	0.05	6.51	88.30
W-Tuy 3	0.72	0.18	20.09	58.26	0.00	0.03	2.06	0.43	0.03	6.27	88.05
Average	0.67	0.15	20.32	59.29	0.00	0.03	2.17	0.49	0.04	6.48	89.64
W-F/Wall	0.82	0.10	24.21	61.80	0.00	0.00	2.58	0.57	0.10	7.00	97.18
W-F/Wal 2	0.70	0.11	21.60	60.53	0.00	0.00	1.75	0.50	0.10	8.23	93.52
W-F/Wal 3	0.56	0.15	23.98	59.29	0.00	0.00	2.03	0.65	0.02	6.78	93.46
Average	0.69	0.12	23.26	60.54	0.00	0.00	2.12	0.57	0.07	7.34	94.72
Ores											
W-ore 1	0.20	0.00	1.52	2.80	0.15	0.13	0.00	0.01	0.05	76.09	80.95
W-ore 2	0.09	0.03	1.35	2.68	0.15	0.13	0.00	0.01	0.04	85.75	90.22
W-ore 3	0.00	0.00	1.49	3.20	0.15	0.15	0.00	0.01	0.05	91.72	96.77

Average	0.10	0.01	1.45	2.89	0.15	0.14	0.00	0.01	0.05	84.52	89.31
W-ore 4	0.18	0.00	13.34	47.45	0.16	0.13	0.00	0.01	0.06	35.23	96.56
W-ore 5	0.12	0.00	19.36	58.67	0.16	0.12	0.00	0.01	0.04	17.79	96.27

Demera

	Na2O %	MgO %	Al2O3 %	SiO2 %	P2O5 %	K2O %	CaO %	TiO2 %	MnO %	FeO %	Total
Furnace slag											
D1	0.39	0.39	4.59	13.61	0.47	1.72	0.97	0.12	0.25	83.37	105.88
D2	0.22	0.19	7.57	14.43	0.36	1.16	0.46	0.32	0.60	77.75	103.06
D3	0.27	0.70	7.69	17.40	0.36	2.41	1.06	0.25	0.40	72.70	103.24
D4	0.52	0.71	7.53	17.13	0.31	2.37	1.04	0.25	0.40	76.23	106.49
D5	0.30	0.55	3.27	16.29	0.70	0.97	1.02	0.11	0.08	81.49	104.78
Average	0.34	0.51	6.13	15.77	0.44	1.73	0.91	0.21	0.35	78.31	104.69
Smithing slag/crown material											
D6	0.29	0.54	5.89	18.52	0.88	1.12	1.07	0.13	0.45	83.93	112.82
D7	0.33	0.18	4.88	14.23	0.29	1.57	0.89	0.28	0.10	87.56	110.31
D8	0.41	0.62	7.78	15.96	0.33	2.42	1.77	0.23	0.34	75.41	105.27
D9	0.25	0.19	7.05	14.71	0.42	2.19	0.99	0.17	0.07	81.68	107.72
D10	0.20	0.28	6.67	13.93	0.23	1.79	1.11	0.12	0.29	78.73	103.35
Average	0.30	0.36	6.45	15.47	0.43	1.82	1.17	0.19	0.25	81.46	107.89
Udiagnostic											
D11	0.37	0.74	7.43	16.95	0.69	1.84	0.86	0.16	0.14	80.17	109.35
D12	0.28	0.77	6.79	13.65	0.36	2.13	1.19	0.15	0.09	79.01	104.42
D13	0.43	0.61	8.02	19.84	1.97	2.28	1.23	0.13	0.25	78.23	112.99
Average	0.22	0.42	7.41	16.81	1.01	2.08	1.09	0.14	0.16	79.14	108.92

Nyamuzihwa Falls

Tap slag	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
NF1	0.40	0.49	5.74	18.38	0.36	0.76	0.89	0.21	0.12	73.94	101.28
NF2	0.26	0.62	5.83	14.62	0.35	0.97	1.19	0.21	0.13	79.92	104.08
NF3	0.42	0.55	6.17	19.49	0.55	1.14	1.26	0.21	0.13	76.77	106.69
NF4	0.55	0.95	9.85	26.02	1.21	2.74	2.64	0.31	0.16	68.09	112.52
NF5	0.46	0.65	6.98	18.23	1.19	3.01	1.32	0.30	0.12	76.56	108.82
NF6	0.48	0.51	8.32	17.34	0.38	1.89	1.45	0.22	0.12	72.33	103.04
NF7	0.51	0.64	5.89	19.21	1.03	0.89	1.93	0.21	0.12	75.23	105.66
Average	0.44	0.63	6.07	19.04	0.72	1.63	1.52	0.24	0.13	74.69	106.01
Furnace slag											
NF8	0.43	0.51	5.73	15.18	0.35	0.76	0.88	0.21	0.12	80.53	104.70
NF9	0.27	0.55	6.24	17.52	0.56	1.15	1.24	0.21	0.13	76.56	104.43
NF10	0.55	0.65	7.58	20.11	0.65	1.36	1.41	0.21	0.13	83.44	116.09
NF11	0.45	0.59	8.60	19.34	1.24	0.99	1.47	0.21	0.13	70.12	103.14
NF12	0.60	0.71	5.98	13.97	1.63	1.21	1.69	0.30	0.13	77.33	103.55

NF13	0.45	0.53	6.76	17.21	1.15	1.34	0.99	0.19	0.17	76.13	104.92
Average	0.46	0.59	6.82	17.22	0.93	1.14	1.28	0.22	0.14	77.35	106.14
Smithing slag											
NF14	0.53	0.66	5.89	14.79	0.46	0.78	1.05	0.21	0.13	88.97	113.47
NF15	0.57	0.62	6.79	15.83	0.71	1.06	0.81	0.22	0.12	78.10	104.83
NF16	0.46	0.67	7.43	14.98	0.93	2.71	0.93	0.21	0.13	80.21	108.66
Average	0.52	0.65	6.70	15.20	0.70	1.57	0.93	0.21	0.13	82.43	108.97
Undiagnostic											
NF17	0.55	0.70	7.71	15.61	0.45	0.88	1.22	0.23	0.12	80.12	107.59
NF18	0.39	0.67	7.93	15.98	0.57	1.45	1.29	0.23	0.14	75.12	103.77
Average	0.47	0.66	7.82	15.80	0.51	1.17	1.26	0.23	0.13	77.62	105.68

Nyamurondo Homestead

Tap slag	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
NH 1	0.71	1.23	9.65	27.78	1.06	2.26	4.13	0.56	0.16	65.23	112.77
NH 2	0.64	1.34	8.99	24.23	1.34	2.03	5.11	0.47	0.19	63.56	107.90
NH 3	0.77	1.61	8.92	23.38	1.14	1.84	4.85	0.47	0.19	65.78	108.94
NH 4	0.65	1.27	8.46	21.35	1.66	2.98	5.03	0.35	0.19	64.32	106.26
NH 5	0.54	0.67	11.29	30.21	0.45	2.07	3.07	0.51	0.17	59.19	108.17
NH 6	0.77	1.46	11.65	20.56	1.06	3.56	4.36	0.44	0.19	67.89	111.94
NH 7	0.68	0.90	10.79	26.87	0.69	1.87	3.11	0.48	0.17	69.15	114.71
NH 8	0.53	1.45	8.33	20.19	0.89	1.25	4.17	0.75	0.18	68.17	105.91
Average	0.66	1.24	9.76	24.32	1.04	2.23	4.23	0.50	0.18	65.41	109.58
Furnace slag											
NH 9	0.77	1.23	8.99	25.65	1.09	2.34	4.19	0.58	0.18	69.83	114.85
NH 10	0.66	1.76	10.23	27.42	0.51	1.98	3.87	0.32	0.18	71.65	118.58
NH 11	0.67	1.03	9.11	25.39	1.31	1.69	3.25	0.46	0.19	73.43	116.53
NH 12	0.72	0.99	6.13	17.28	1.99	2.23	5.16	0.34	0.19	70.81	105.84
NH 13	0.72	1.96	7.45	21.88	0.89	1.77	4.23	0.67	0.15	68.48	108.20
NH 14	0.68	1.62	8.32	21.27	1.76	2.65	3.51	0.58	0.15	75.13	115.67
NH 15	0.52	0.79	12.01	26.18	0.71	1.56	3.21	0.44	0.18	67.78	113.38
NH 16	0.43	0.91	5.98	18.67	0.99	1.21	5.12	0.55	0.19	71.09	105.14
NH 17	0.47	0.84	7.72	21.56	0.54	1.36	4.23	0.54	0.19	69.98	107.43
Average	0.62	1.24	8.44	22.81	1.09	1.87	4.08	0.50	0.18	70.90	111.74
Smithing slag/ crown material											
NH 18	0.54	1.08	4.13	16.09	0.78	1.96	3.86	0.36	0.19	77.42	106.41
NH 19	0.67	1.45	6.98	22.67	0.43	1.50	3.97	0.43	0.15	75.79	114.04
NH 20	0.75	0.96	7.89	23.43	1.02	2.43	2.98	0.31	0.19	68.78	108.74
Average	0.65	1.15	6.33	20.73	0.74	1.96	3.60	0.37	0.18	73.99	109.73
Undiagnostic											
NH 21	0.65	0.76	6.78	21.33	0.91	2.41	4.08	0.30	0.18	67.98	105.38

NH 22	0.75	1.06	7.89	24.54	1.87	1.73	5.11	0.78	0.21	61.96	105.90
NH FS	1.02	1.46	12.11	32.42	0.74	2.81	5.11	0.43	0.18	79.19	135.47
Average	0.81	1.09	8.93	26.10	1.17	2.32	4.77	0.50	0.19	69.71	115.58
Technical ceramics											
NH tuy	1.01	0.51	26.59	56.27	0.04	2.86	0.36	0.42	0.01	6.25	94.32
NH tuy	0.92	0.31	21.11	61.17	0.02	4.24	0.92	0.41	0.02	5.97	95.09
NH tuy	1.02	0.52	22.45	65.12	0.01	3.12	0.67	0.25	0.12	3.67	96.95
Average	0.98	0.45	23.38	60.85	0.02	3.41	0.65	0.35	0.05	5.30	95.45
NH f/wall 1	0.31	0.46	19.42	60.57	0.05	4.97	1.16	0.57	0.06	4.37	91.94
NH f/wall 2	0.43	0.45	21.76	58.91	0.05	4.87	0.79	0.56	0.67	3.39	91.88
NH f/wall 3	0.89	0.62	25.78	61.06	0.07	2.89	0.61	0.60	0.02	4.12	96.66
Average	0.54	0.51	22.32	60.18	0.06	4.24	0.85	0.58	0.25	3.96	93.49

Upper Pungwe

Smithing slag/ crown material

	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
UP1	0.15	0.09	6.82	14.74	0.33	0.87	0.39	0.30	0.51	85.27	109.46
UP2	0.38	0.62	7.52	16.94	0.50	2.31	1.04	0.24	0.40	80.26	110.21
UP3	0.30	0.40	5.50	13.30	0.60	0.80	0.50	0.30	0.50	90.60	112.80
UP4	0.63	0.03	6.69	11.53	0.39	0.41	0.16	0.26	0.39	91.09	111.58
UP5	0.35	0.41	10.34	15.39	0.52	1.18	0.51	0.37	0.61	86.20	115.88
UP6	0.44	0.56	7.87	15.41	0.78	1.86	0.65	0.45	0.76	85.09	113.87
UP7	0.56	0.71	7.86	15.34	0.51	2.86	1.02	0.32	0.47	84.12	113.77
UP8	0.41	0.73	10.31	16.72	0.49	1.15	0.50	0.32	0.55	83.21	114.39
UP9	0.39	0.09	7.07	15.12	0.54	1.43	0.76	0.42	0.63	77.88	104.33
Average	0.41	0.40	7.76	14.94	0.52	1.43	0.61	0.33	0.56	84.85	111.81
Undiagnostic											
UP 10	0.16	0.07	6.71	16.98	0.43	0.91	1.23	0.26	0.54	76.12	103.41
UP11	0.15	0.08	7.12	14.52	0.54	2.15	1.05	0.24	0.40	81.10	107.35
Average	0.16	0.08	6.92	15.75	0.46	1.53	1.14	0.25	0.47	78.61	105.38
Ore											
UP 10	0.11	0.03	3.88	5.78	0.04	0.05	0.02	0.06	0.03	72.03	82.03
UP 11	0.18	0.04	4.12	6.97	0.07	0.10	0.03	0.07	0.02	75.09	86.69
Average	0.15	0.04	4.00	6.38	0.06	0.08	0.03	0.06	0.03	73.56	84.36
UP 13	0.16	0.08	13.16	67.18	0.03	0.12	0.05	0.06	0.03	15.23	96.10
Technical ceramics											
UP f/wall 1	0.21	0.53	24.22	65.91	0.06	2.41	1.86	0.21	0.03	1.78	97.22
UP	0.28	0.61	23.10	60.86	0.08	3.42	1.73	0.25	0.03	5.25	95.61

f/wall 2											
UP f/wall 3	0.27	0.43	24.29	61.33	0.06	4.13	2.21	0.31	0.03	4.81	97.87
Average	0.25	0.52	23.87	62.70	0.07	3.32	1.93	0.27	0.03	3.95	96.90

Nyahokwe 8

Furnace slag

	Na2O	MgO	Al2O3	SiO2	P2O5	K2O	CaO	TiO2	MnO	FeO	Total
N 8 1	0.84	1.83	9.43	22.99	0.79	1.89	6.28	0.39	0.23	61.28	105.95
N 8 2	0.92	1.54	10.41	23.43	0.76	1.78	4.89	0.40	0.21	66.21	110.55
Average	0.88	1.69	9.92	23.21	0.76	1.84	5.59	0.40	0.22	63.76	108.25
Technical ceramics											
N 8f/wall	0.61	0.43	21.99	62.73	0.06	4.21	1.28	0.57	0.23	3.52	95.63
N 8f/wall 2	0.72	0.32	19.43	60.12	0.02	3.88	2.23	0.42	0.22	4.31	91.67
N 8f/wall 3	0.51	0.64	20.56	59.81	0.05	4.29	1.66	0.45	0.23	3.65	91.85
Average	0.61	0.46	20.66	60.89	0.04	4.13	1.72	0.48	0.27	3.83	93.05
N 8tuy	1.23	0.66	18.56	63.26	0.05	3.91	1.97	0.53	0.22	5.22	95.61
Old Site Museum											
Tap slag											
OSM 1	0.65	0.97	8.75	24.01	0.47	2.22	4.08	0.29	0.21	62.68	104.33
OSM 2	0.61	0.87	9.23	29.31	0.55	2.48	3.46	0.25	0.21	65.45	112.42
Average	0.63	0.92	8.99	26.66	0.51	2.35	3.77	0.27	0.21	64.07	108.38
Ziwa 1											
Technical ceramics											
Z f/wall 1	0.91	1.02	20.31	59.94	0.06	3.76	4.21	0.45	0.13	6.71	97.50
Z f/wall 2	0.88	0.96	19.56	61.86	0.06	2.43	3.96	0.29	0.12	4.56	94.68
Z f/wall 3	0.92	1.03	20.44	60.41	0.07	2.74	3.78	0.46	0.15	8.86	98.86
Z f/wall 4	0.81	1.43	13.10	72.90	0.13	4.27	3.28	0.49	0.10	3.56	98.90
Average	0.88	1.11	18.35	63.78	0.08	3.30	3.81	0.42	0.13	5.92	97.49
Sangura Hill											
S 1 tuy 1	0.88	0.97	18.50	65.60	0.10	4.08	2.24	0.26	0.04	4.38	97.05
S 1 tuy 2	0.96	1.31	19.51	61.21	0.13	4.17	3.16	0.31	0.06	5.22	96.04
	0.92	1.14	19.01	63.41	0.12	4.13	2.70	0.29	0.05	4.80	96.55

S 1 f/wall	0.86	1.52	18.26	63.68	0.13	4.13	1.97	0.29	0.05	6.21	97.10
S 1 f/wall	0.87	1.05	21.43	60.17	0.18	3.83	2.21	0.31	0.09	3.27	93.41
	0.87	1.29	19.85	61.93	0.16	3.98	2.09	0.30	0.07	4.74	95.26

Appendix 3: XRF Results: Trace elements

Swart Village	Co3O4	NiO	CuO	ZnO	Rb2O	SrO	ZrO2	Ba	Ce	PbO	Th
Tap Slag	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
SVT2 L2	43	50	31	41	56	109	206	522	53	5	9
SVT1 L1	81	74	28	39	44	185	233	400	34	2	7
STV1 L3	302	52	110	101	40	207	212	540	54	2	2
SVT2 L3	83	43	27	42	49	117	237	468	43	9	9
SVT2 L1	70	45	32	43	48	110	220	490	58	7	10
SVT2 L2	264	58	139	90	44	163	208	351	40	2	2
SVT2 L3	291	49	121	85	37	197	265	279	38	2	1
SVT4 L1	198	56	76	47	51	181	224	321	37	3	1
Average											
Furnace Slag											
SVT3 L2	46	43	25	52	46	97	197	457	41	7	3
SVT1L3	78	61	32	44	39	127	213	389	34	4	1
SVT2 L2	288	33	103	97	32	178	199	620	49	1	8
SVT1 L1	77	28	65	57	43	98	230	425	36	5	2
SVT1 L2	68	48	36	45	39	104	203	221	45	3	9
SVT1 L3	261	44	124	86	39	171	211	386	29	3	1
SVT1 L3	272	38	143	81	32	178	201	234	27	1	5
Average											
Smithing slag/Crown material											
SVT2 L2	55	39	41	54	66	95	166	228	77	1	4
SVT2 L3	186	45	122	87	36	201	189	452	51	4	7
SVT31 L3	210	55	149	77	40	170	290	367	41	1	1
SVT4 L2	155	43	89	54	45	210	231	298	44	2	1
SVT1L4	70	51	39	50	42	125	189	234	33	2	1
SVT2 L2	215	34	118	78	46	182	224	321	23	2	5
SVT3 L1	261	41	121	98	45	215	256	308	33	6	1
Average											
Undiagnostic Slag											
SVT1 L2	196	29	162	89	55	222	278	398	33	4	2
SVT1 L3	134	52	75	46	61	187	205	227	36	9	1
SVT1 L1	89	61	38	65	51	109	211	323	56	1	3
Average											

Furnace Wall											
SVT1 L4	43	50	31	41	56	109	206	522	35	53	5
SVT1 L3	81	74	28	39	44	185	233	400	12	34	2
SVT2 L3	302	52	110	101	40	207	223	540	19	54	2
Average											
Tuyeres	291	49	137	85	37	154	208	279	14	38	2
SVT1 L3	83	43	27	42	49	117	223	468	22	43	9
SVT2 L3	70	45	32	43	48	110	220	490	35	58	7
SVT2 L4	264	58	139	90	44	126	208	351	15	40	2
Average											
Ores											
SVT2 L3	201	34	123	64	56	165	123	206	16	39	2
SVT2 L3	321	45	165	78	43	154	217	234	15	37	1
Average											
SVT2 L2	213	43	121	45	29	176	199	287	10	27	0
SVT3 L2	189	54	108	52	31	152	172	227	13	34	1
Ceramic materials											
SVTp1L4 BLi	211	47	157	88	43	161	197	326	12	21	1
SVTr2L2 Pott	191	38	129	96	29	175	183	298	3	1	1
SVTP1L3 P/D	61	56	29	38	42	188	234	318	4	8	2
Barands	Co3O4	NiO	CuO	ZnO	Rb2O	SrO	ZrO2	Ba	Ce	PbO	Th
Tap Slag	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
BN T3 L4	410	19	47	4	6	1	51	468	49	26	25
BN T1 L2	300	15	55	1	5	46	86	539	55	17	15
BN T2 L1	4	25	97	2	7	2	23	75	35	37	30
BNT3 L4	380	21	39	4	6	2	31	364	33	24	23
BN T3 L1	310	19	41	2	6	27	59	412	32	23	21
BN T1 L2	410	22	37	1	6	5	51	247	41	27	26
Average											
Furnace Slag											
BNT1L2	187	17	39	5	5	1	38	279	32	22	21
BNT2 L3	360	21	40	6	5	1	40	345	33	23	21
BN T2 L2	420	22	74	4	6	10	27	254	40	27	25
BNT1L1	270	18	30	4	5	1	53	268	38	22	20
BNT1L2	4	28	46	1	7	3	18	51	35	34	32
BNT2 L3	535	12	87	23	4	105	85	106	28	16	14
BN T3 L1	4	26	42	1	7	3	25	42	35	34	32
BN T3 L2	321	12	59	18	4	104	75	113	24	16	13
BN T3 L3	100	5	7	1	1	1	14	28	16	5	5
BN T1 L3	270	11	15	3	4	18	50	171	24	14	14
BN T1 L4	54	2	4	1	1	0	8	63	68	2	2
BN T3 L3	220	17	50	29	6	2	28	7	27	27	23

Smithing slag											
BN T1 L3	183	15	14	29	5	76	45	230	26	22	18
BNT1L1	110	33	64	20	7	10	19	332	27	1	6
BNT1 L1	90	59	41	20	6	1	11	289	20	1	6
BN T3 L4	78	46	13	22	5	27	21	253	21	23	13
BN T3 L4	15	28	17	20	6	22	33	56	44	153	44
BN T1 L1	78	28	18	21	1	2	9	111	67	36	18
Average											
Undiagnostic slag											
BN T3 L3	43	51	43	26	4	31	32	188	21	45	17
BNT3L4	75	55	12	48	7	22	15	64	27	1	7
BN T3 L3	62	29	11	37	1	29	17	214	32	21	15
Average											
Furnace Wall											
BNT2 L2	108	25	18	31	166	221	254	1079	44	153	44
BNT3 L4	113	69	52	59	109	250	241	1292	67	36	18
BNT2L2	121	72	68	43	133	210	189	1005	45	23	16
Average											
Tuyeres											
BNT3 L2	101	77	53	57	88	359	159	1254	25	32	13
BNT1L2	21	15	12	26	166	221	254	1079	44	153	44
BNT1L3	76	13	11	21	88	107	165	321	54	31	11
	172	77	29	41	43	191	236	409	39	1	7
Average											
Ores											
BN T1 L3	105	32	41	33	6	89	54	116	22	21	19
BN T3 L3	200	14	51	17	5	99	63	102	28	23	19
Average											
Ceramic materials											
BNT3 L2 pot	271	129	115	74	16	123	81	1007	2	1	1
BNT1L3 pot	406	78	78	23	76	289	121	1163	28	17	2
BN T2 L1 H/F	161	34	98	56	61	179	221	419	42	15	7
Wedza											
	Co3O4	NiO	CuO	ZnO	Rb2O	SrO	ZrO2	Ba	Ce	PbO	Th
Tap Slag	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
W-Fs1	561	17	70	43	4	90	57	397	26	15	12
W-Fs2	844	15	155	27	6	3	73	8	27	26	21
W-Fs3	960	16	149	20	6	2	96	7	25	26	21
W-Fs9	460	28	95	33	4	118	58	475	27	15	12
W-Fs2	605	51	92	37	13	139	60	608	45	12	11
W-Fs3	422	49	45	25	4	109	73	422	26	17	14
W-Fs1	1046	21	291	24	6	2	71	35	35	24	19
W-Fs6	840	235	150	34	9	128	75	562	33	13	11
W-Fs2	530	22	34	37	5	89	53	347	35	21	17

Average											
Furnace Slag											
W-Fs4	537	18	57	34	4	120	177	492	34	16	13
W-Fs5	565	17	143	33	4	91	161	430	23	14	11
W-Fs6	723	33	132	41	3	97	65	488	41	20	12
W-Fs7	389	29	112	36	5	104	81	98	33	13	17
W-Fs8	541	21	49	22	4	89	173	376	34	16	10
W-Fs9	429	23	35	20	4	92	177	496	26	18	14
W-Fs4	522	27	31	26	2	152	69	86	27	14	10
Average											
Smithing Slag/Crown Material											
W-Cr1	1011	21	950	22	7	5	63	119	45	30	24
W-Cr2	965	20	987	30	7	7	71	110	28	30	24
W-sm3	845	18	267	31	6	7	91	125	33	28	22
W-sm1	818	16	179	32	6	2	84	8	26	26	22
W-sm2	791	22	255	23	6	4	64	28	26	23	20
Average											
Undiagnostic Slag											
W-T1	483	20	53	27	5	87	62	346	27	20	16
W-Fs16	612	25	53	22	7	97	64	338	21	20	17
Average											
Technical ceramics											
W-Tuy 1	94	31	33	41	151	76	149	319	108	45	24
W-Tuy 2	119	32	60	38	136	70	144	279	98	36	22
W-Tuy 3	101	31	45	34	148	61	147	428	89	31	18
Average											
W- F/Wall	102	37	56	36	135	66	154	272	97	37	21
W-F/Wal 2	123	30	39	39	150	76	146	327	113	48	23
W-F/Wal 3	98	30	45	37	146	71	141	320	108	41	22
Average											
Ores											
W-ore 1	747	122	47	60	6	2	70	7	25	26	21
W-ore 2	953	30	98	65	6	2	77	7	26	26	22
W-ore 3	957	73	114	60	6	2	67	8	26	28	23
Average											
W-ore 4	856	89	45	58	6	3	58	9	31	23	16
W-ore 5	561	65	52	41	4	6	47	8	26	21	16
	Co3O4	NiO	CuO	ZnO	Rb2O	SrO	ZrO2	Ba	Ce	PbO	Th
Demera	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
Furnace slag											

D1	33.2	10.3	42.4	33.9	207	47.5	222	311	124	51.3	78.6
D2	1086	22	1094	22.1	6.9	37.7	122	164	27.7	26	22
D3	953	22	1131	33.2	6.9	39.1	105	163	38.6	27	21
D4	927	22	1098	16.9	7	35.8	117	158	41.8	26	21
D5	653	13	82	18.8	6	1.9	173	257	175.9	21	17
Smithing slag/crown material											
D6	663	14	43.4	15.1	25.2	1.8	148	259	183.1	22	17
D7	741	16	623	23.8	63.9	48.2	115	201	83.3	21	17
D8	648	16	591	16.2	62.4	44.3	93.2	206	86.9	21	17
D9	727	16	619	24.4	55	48.8	105	191	86.4	21	17
D10	545	15	628	18.9	61.3	48.3	115	196	64.4	21	17
Udiagnostic											
D11	628	20	260.2	23.9	6.3	18	45.1	18.6	24.7	26	22
D12	936	20	258.8	28.4	6.3	19.4	59.5	24.4	28	26	21
D13	738	21	267	21	6.1	18	61	197	31	24	18
Nyamuzihwa Falls											
Tap slag											
NF1	814	17	617	24.9	6.3	17.7	112	38.3	64.9	25	21
NF2	640	17	570	24.4	6.1	16.1	107	35.1	65.8	25	20
NF3	2510	20	560	22.5	6.6	48.8	89.2	45	98	22	22
NF4	629	16	484	33	6.2	44.6	99.5	56	91.7	25	20
NF5	910	15	433	17.1	6.2	41.5	114	53.8	83	25	21
NF6	938	16	655	14.8	6.1	45.5	105	97.2	114.6	24	19
NF7	1029	15	670	6.4	6.1	45.3	106	94	106.6	24	19
Furnace slag											
NF8	904	17	579	21.1	6.2	15.6	84.1	29.8	86.7	25	21
NF9	740	17	579	17.9	6.1	15.4	114	37.5	83.4	26	21
NF10	858	16	670	20.3	6.1	41.3	105	104	115.2	23	19
NF11	873	15	654	21.1	6.1	44.1	78.5	95.5	89.3	24	19
NF12	728	15	621	21	6	43	77	93	87	23	19
NF13	629	16	561	22	6	39	71	90	85	21	18
Smithing slag											
NF14	827	18	537	18	6	17	98	23	89	23	19
NF15	742	19	623	19	6	19	121	78	102	25	21
NF16	683	21	542	17	7	21	98	61	78	21	18
Undiagnostic											
NF17	828	27	489	23	8	16	85	99	77	21	18
NF18	561	23	521	19	6	17	91	1.2	81	21	17
Nyamurondo Homestead											
	Co3O4	NiO	CuO	ZnO	Rb2O	SrO	ZrO2	Ba	Ce	PbO	Th
Tap slag	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
NH 1	700	10	159	51	57	328	237	322	343	13	11
NH 2	608	10	143	48	53	330	243	327	299	14	12
NH 3	545	10	146	54	51	315	221	327	340	14	11
NH 4	641	10	186	58	62	340	253	313	310	14	11
NH 5	576	10	195	56	65	389	261	318	307	14	11
NH 6	602	10	151	47	71	339	267	321	310	14	12

NH 7	610	10	154	49	68	299	254	331	324	14	11
NH 8	532	10	156	45	56	310	243	287	316	13	11
Furnace slag											
NH 9	781	8.8	161	45	57	329	209	319	322	13	11
NH 10	561	10	119	32	67	328	267	398	278	14	12
NH 11	678	10	135	46	51	287	174	398	314	14	12
NH 12	671	10	138	45	58	296	211	345	307	14	11
NH 13	429	10	195	41	61	298	231	341	319	14	11
NH 14	488	10	165	49	53	387	265	345	351	13	11
NH 15	602	10	121	33	57	325	261	393	279	15	12
NH 16	457	10	178	51	46	321	281	342	298	17	14
NH 17	523	10	185	50	45	288	271	365	314	14	11
Smithing slag/ crown material											
NH 18	761	10	196	41	56	324	207	321	319	14	11
NH 19	562	10	189	40	55	319	213	301	285	14	12
NH 20	689	11	276	45	50	339	284	321	268	13	11
Undiagnostic											
NH 21	747	10	197	56	65	328	215	289	276	14	11
NH 22	561	10	163	51	63	311	275	341	322	14	12
NH FS	487	10	165	55	61	319	287	311	287	13	11
Technical ceramics											
NH tuy	211	21	148	41	61	523	211	412	121	46	41
NH tuy	301	23	167	41	67	456	286	513	156	43	39
NH tuy	289	27	176	40	65	365	211	548	134	56	51
NH f/wall 1	251	25	165	43	62	343	254	542	152	44	40
NH f/wall 2	201	31	231	48	74	561	243	498	178	47	44
NH f/wall 3	254	33	241	56	85	534	231	487	132	46	41
Upper Pungwe											
Smithing slag/ crown material											
UP1	824	13	199	31	6	2	162	156	175	22	18
UP2	1046	13	168	21	6	2	158	169	155	22	18
UP3	517	17	701	21	55	42	117	194	56	21	17
UP4	678	16	735	30	59	46	116	215	52	21	17
UP5	688	14	186	20	6	2	172	161	180	22	18
UP6	889	14	200	28	6	2	136	175	187	22	18
UP7	588	12	443	23	6	2	135	143	131	22	18
UP8	319	11	224	26	6	2	134	171	148	22	18
UP9	489	11	231	35	6	2	141	167	156	22	17
Undiagnostic											
UP 10	765	12	186	32	6	2	145	187	157	21	17
UP11	451	11	221	31	6	2	163	203	181	21	17
Ore											
UP 10	35	12	49	33	208	47	212	306	128	52	78
UP 11	28	13	41	34	205	48	213	310	130	52	79
UP 13	31	11	45	26	210	49	216	329	135	53	76

Technical ceramics											
UP f/wall 1	615	11	264	21	6	2	112	523	141	27	24
UP f/wall 2	718	11	231	23	6	2	98	487	152	28	24
UP f/wall 3	679	10	214	23	6	3	105	512	139	31	27
Nyahokwe 8											
Furnace slag											
N 8 1	325	14	139	11	23	254	128	305	256	11	9
N 8 2	441	14	177	11	26	213	145	287	310	10	9
Technical ceramics											
N 8f/wall	271	21	231	35	28	275	167	487	319	32	28
N 8f/wall 2	368	27	226	31	33	261	172	512	289	33	28
N 8f/wall 3	396	31	209	41	54	288	175	398	219	39	35
N 8tuy	387	35	218	45	52	209	178	602	318	26	21
Old Site Museum											
Tap slag											
OSM 1	521	12	126	47	33	188	89	218	189	12	8
OSM 2	518	13	125	42	31	145	101	187	172	13	8
Ziwa 1											
Technical ceramics											
Z f/wall 1	306	27	245	31	23	265	154	389	334	41	37
Z f/wall 2	356	34	235	36	26	243	125	451	276	40	36
Z f/wall 3	387	41	242	35	25	270	167	401	332	41	37
Z f/wall 4	412	42	231	34	26	284	186	412	334	41	37
Sangura Hill											
S 1 tuy 1	563	35	189	23	18	287	123	879	278	56	52
S 1 tuy 2	645	43	194	21	19	233	118	756	304	60	54
S 1 f/wall	489	51	165	29	18	189	131	588	312	61	55
S 1 f/wall	523	52	147	31	19	247	129	612	316	63	54